TESTING STRATIGRAPHIC INTEGRITY OF UPPER AND MIDDLE PALEOLITHIC DEPOSITS IN VINDIJA CAVE (CROATIA):
A Chipped Stone Refitting Analysis

By

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Submitted to the Department of Anthropology and the Faculty of the Graduate School of the University of Kansas in Partial Fulfillment of the Requirements for the degree of Masters of Arts

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Date Approved: May 11, 2009

ABSTRACT

Vindija Cave in northwest Croatia contains cultural materials and archaic human remains significant for understanding the Middle to Upper Paleolithic transition in Central Europe. Unresolved issues pertaining to the stratigraphic integrity of these deposits has led to debate over their interpretation. The goals of this thesis are to determine if vertical movement of archaeological materials has occurred and what effects such movement may have on the composition of the cultural assemblages. Systematic refitting of the chipped stone assemblage within and between all stratigraphic levels at Vindija Cave was carried out and five percent of the assemblage was successfully refit. The vertical distribution of refitting artifacts throughout the Upper and Middle Paleolithic deposits demonstrates that post-depositional movement has occurred between stratigraphic levels. Refitting data underscores the importance of consideration for the role post-depositional processes may have had on the integrity of cultural assemblages at this site.

ACKNOWLEDGMENTS

I would very much like to thank Ivana Radovanović for her mentoring, inspiration, and unending support during the process of writing this thesis. I also wish to thank Jack Hofman for his contribution to this work and for so many years of sharing his insight into all matters archaeological. The other members of my committee, David Frayer and Rolfe Mandel, and Ivor Karavanić have provided very helpful comments from which this thesis has greatly benefited and for which I am very grateful.

I am indebted to Dejana Brajković and the entire staff of the Institute for Quaternary Paleontology and Geology in Zagreb for welcoming me into the zavod, providing me with a place to work, and for all of their assistance during my stay there. Jakov Radovčić and Darko Rukavina filled in critical blanks regarding the excavations at Vindija Cave and I thank them for sharing their experiences.

This work has benefited greatly from discussions and comments with many friends and colleagues including Jess Craig, Janice Mclean, Siniša Radović , Shannon Ryan, and Chris Widga, among others. I am particularly grateful to Kelly Speight and Ginny Hatfield for their support and encouragement during some critical points. I also want to thank Judy Ross for keeping me on track and on time and helping me negotiate all the administrative tasks associated with this process.

Special thanks are in order to my family and friends who have been overwhelmingly supportive through the writing of this thesis, and especially to Jess Anthony for keeping me in touch with ONJ. Edward McGowan went far beyond the call of duty and translated several articles from German to English. I am grateful to him for that, and much more.

This thesis has benefited greatly from discussions with each of the people listed above and others, any and all errors in this thesis are, however, mine alone. Research for this thesis was funded by a Fulbright Grant from the International Education Commission, and supporting funds were provided by the Carroll Clark Award and the Carlyle Smith Award.

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Chapter 1: Introduction

The stratified Upper and Middle Paleolithic deposits of Vindija Cave in northwest Croatia have produced archaeological materials and remains of archaic humans with the potential to contribute considerably to the understanding of biological and cultural dynamics in southeastern Central Europe during the Middle to Upper Paleolithic transition. Questions concerning the stratigraphic integrity of these deposits, however, cloud the potentially very significant role this site may play in understanding late Pleistocene cultural and biological processes prior to the disappearance of Neandertals from the archaeological record. Central to this question are the chronology and evolutionary relationships of the earliest Upper Paleolithic industries in South and Central Europe, such as the Szeletian, Bohunician, and Uluzzian, as well as others, to the traditional marker of the Upper Paleolithic: the wide-ranging Aurignacian techno-complex (Brantingham et al 2004a, Hays and Thacker 2001).

The stratigraphic integrity and interpretation of the cultural materials and human skeletal remains from Level G1 at Vindija is a source of debate (d'Errico et al 1998, Zilhão and d'Errico 1999a, Karavanić and Smith 2000, Straus 1999). Artifacts from Level G1 include both Middle and Upper Paleolithic stone tool types (Karavanić 1995, Karavanić and Smith 1998) including a bifacial foliate point of possible Szeletian affinity, and bone points generally associated with the Aurignacian. This level also produced at least six fragmentary remains of archaic humans which, in those specimens with diagnostic morphological attributes, exhibit Neandertal morphology (Wolpoff et al 1981, Smith 1984, Ahern et al 2004). This unusual association of artifacts in association with late occurring Neandertals (33,000 – 34,000 rcybp) exhibiting morphological features approaching the conditions of anatomically modern humans, is seen by some as possibly evidence of localized development of the Upper Paleolithic independent of the influence from modern humans (Karavanić 1995, Karavanić and Smith 1998, Straus 1999, Wolpoff et al 1981). Others suggest the co-occurrence of Upper and Middle Paleolithic tool types is the result of the mixing of sediments as a result of natural processes (Zilhão and d'Errico 1999b, Kozłowski 1996).

Evaluation of the contextual integrity of all archaeological deposits is essential before the patterning and association of artifacts is interpreted in behavioral terms. Radiometric assays have demonstrated some chronological inversions through the vertical profile at Vindija (Wild et al 2001) and it remains uncertain whether this reflects the actual temporal relationship of materials between and within strata, and therefore, evidence of mixing of deposits, or if the incongruous dates are the result of differential pre-treatment of samples (e.g. Smith et al 1999, Higham et al 2006) or other problematic issues related to the interpretation of radiocarbon dates during this critical time frame.

The goal of this thesis is to take preliminary steps toward the resolution of the stratigraphic question at Vindija with the application of refitting analysis. The refitting of artifacts that have been broken or are separated is a relatively simple method by which the vertical relationship of artifacts can be demonstrated and is one of many lines of evidence through which the contextual integrity of an archaeological assemblage may be evaluated. In so doing, refitting allows for the interpretive strength and analytical value of archaeological assemblages to be increased substantially.

Vertical migration of artifacts from their original location of deposition is not uncommon in either caves and rockshelters or open-air sites. A variety of natural and cultural factors such as trampling, recycling of implements, burrowing by animals, water flow and saturation, frost-heave, and shrink-swell have been shown to contribute to the vertical displacement of artifacts (Stockton 1973, Moeyersons 1978, Cahen and Moeyersons 1977, Wood and Johnson 1978, Villa 1982, Villa and Courtin 1983, Erlandson 1984, Gifford-Gonzalez et al 1985, Hofman 1986). Utilizing refitting data from Terra Amata, Villa (1982, 1983) demonstrated that artifacts may move between and even pass completely through geological strata as a result of post-depositional processes, even in cases where no obvious signs of disturbance were observed in the sediments.

Results of refitting analysis of the Vindija materials raises questions regarding site formation processes, some of which are briefly explored in this thesis, as well as the role that these processes may have played in the composition of archaeological assemblages. If the association of materials in Level G1 at Vindija were shown to be tenable, it would provide evidence of a localized manifestation of an Early Upper Paleolithic industry in Central Europe and directly link Neandertals to this industry. As with the Neandertal – Châtelperronian association at Saint-Césaire in France, such an association would strengthen the argument for the *in situ* development of other transitional industries of South and Central Europe such as the Szeletian, Bohunician, and Ulluzian. Most remarkable would be the direct association of Neandertals with type fossils generally associated with the Aurignacian techno-complex, which historically has been considered to mark the presence of anatomically modern humans in Europe.

Chapter 2 provides a brief description of the geological and paleoenvironmental settings of Vindija and the Hrvatsko Zagorje region. This is followed by a summary of the history of investigations at Vindija and the current state of research on those materials recovered from the Paleolithic deposits in Chapter 3.

Research strategy of this study and methods and materials utilized are presented in Chapter 4. The utility of refitting as an analytical tool in archaeology, especially as it pertains to the investigation of vertical movement of artifacts is also discussed, as is a general description of cave taphonomy and the effects post-depositional processes can be expected to have on archaeological materials in cave deposits.

Chapter 5 presents the results of the refitting analysis and addresses the stratigraphic integrity of the archaeological sequence within the Pleistocene deposits at Vindija. The role that post-depositional processes played in site formation and the composition of the cultural assemblages is also discussed.

The thesis is concluded in Chapter 6 with a review of what has been learned regarding the stratigraphic and contextual integrity of the Vindija materials. The significance of this work to the study of the Early Upper Paleolithic of south-central Europe and the Middle to Upper Paleolithic transition is also discussed. Suggestions are made for future research with the aim of achieving a greater understanding of the archaeological record of Vindija Cave.

Chapter 2: Geological and Paleoenvironmental Settings

The Pleistocene epoch began 1.8 million years ago and is the culmination of a long and persistent cooling throughout the Cenozoic era. The Pleistocene is characterized by a relatively unstable climate with several episodes of glacial advances and retreats. Glacial and interglacial cycles of the middle and late Pleistocene are documented in cores from sea floor sediments (Shackleton and Opdyke 1973) and cave sediments (Butzer 1981) that contain records of global or localized changes in atmospheric and environmental conditions. Cultural responses to a changing environment, in terms of both patterns of landscape use and technology, are central to understanding human evolution and lifeways during this period.

The sedimentary deposits at Vindija span the Riss glacial to the Holocene and thus are an important profile on which the middle and late Pleistocene paleoclimate and paleoenvironment of the region are based (Rukavina 1978, 1983, Malez et al 1984). This sub-Alpine region of southeastern Europe has produced skeletal remains of archaic and modern humans and their associated material culture from stratified cave and rockshelter contexts and provides a unique opportunity to investigate human biological and cultural evolution from a regional perspective (Wolpoff et al 1981, Smith 1982, 1984, Smith and Raynard 1980).

2.1 Location and Geological Setting

Vindija Cave is located in southeastern Europe in the northwest of the Republic of Croatia (Figure 2.1) among the relatively low-lying foothills composing the southeastern most extension of the Julian Alps. These uplands are connected to the Danube river system by the Drava and Sava rivers, both of which converge with the Middle Danube River in the nearby Pannonian Basin. Geologically the area in which the site is situated belongs to the Alpine region. It also is situated at the southwestern margin of the Carpathian Plain, of which Pannonian Basin is in the southern portion.

The cave is located on the eastern end of the southeast-northwest stretching uplands known locally as the Ravna Gora. To the northwest these uplands descend to the Drava River valley, which is less than 7 linear kilometers from Vindija. The cave is on the southwest face of Križnjak Peak, 275 meters above sea level, and overlooks the Šokot Creek valley approximately 300 meters upstream from the confluence of the Šokot with the Voća River. The cave is a single chamber approximately 50 meters in length, 28 meters across at its widest point, and more than 10 meters in height. The only entrance to the cave is a semicircular opening approximately 15 meters wide (Figure 2.2).

The cave was created during the middle Pliocene in thick layers of Upper Baden formation limestone as a consequence of folding and splitting of sedimentary layers due to tectonic activity (Malez et al 1984, Šimunić 1992). The modern opening to the cave was created as a result of erosion by stream activity during the Upper Pliocene and was raised above the modern stream valley as a result of the Horostovski uplift of the Ravna Gora.

In geological terms Vindija is more accurately classified as a cave mouth or rockshelter (Goldberg and Mandel 2008). The distinction is significant in that unlike the deep interiors of caves, Vindija is entirely connected to the outside environment. Deposition and weathering of sediments in an open setting such as this differs substantially from that of one isolated from the influences of the outside environment. I will retain the term “cave” as a matter of convention when referring to the site or location.

The accumulation of sediments in Vindija Cave began during the middle Pleistocene. Sediments are predominately silt, deposited by wind and water actions, but also include varying amounts of sand, clay, and limestone detritus originating from the walls and ceiling of the cave (Malez et al 1984). These are the only stratified deposits in the Hrvatsko Zagorje to provide a continuous record stretching from the Riss Glacial through the Holocene. The Vindija deposits were interpreted in the Alpine scheme (Günz-Mindel-Riss-Würm) with lithostratigraphic divisions representing glacial-interglacial cycles. The lowermost strata, Levels M and L, are Riss-aged. The Riss-Würm interglacial is likely represented by Level K. Correlation of the Vindija lithostratigraphy with oxygen isotope stages is hampered by a small number of dated samples and lack of internally consistent numerical ages from these deposits (Paunović et al 2001, Montet-White 1996). Alternating episodes of warm and cold within the Würm Glacial can be observed in the lithostratigraphic divisions of Complex G and the lower portions of Complex F where cryoclastic rubble is common. Complexes G and F are therefore attributed to the OIS 3. OIS 2 is represented by sediments in Level E indicating a relatively short cold and dry period at the Last Glacial Maximum followed by the post-glacial accumulation of large amounts of loess that compose Level D.

Figure 2.1 Location of Vindija Cave.

Figure 2.2 The entrance of Vindija Cave before excavation (top) and in 2005 (bottom). A witness profile (Pyramid I) can be seen in the left of the bottom photo.

2.2 Paleoenvironmental Setting

The Pleistocene is characterized by a relatively unstable climate and dramatic environmental changes resulting from several glacial-interglacial events. The mechanical and chemical weathering of sediments at Vindija as well as the composition of fossil faunal communities provides evidence of changing local environmental conditions in the stratigraphic succession of relative warm/cold and wet/dry periods (Malez and Rukavina 1979, Malez et al 1984, Rukavina 1978, 1983).

Vindija is located in the Alpine region of the Southern Province according to Gamble's regional model of Europe (1986: 73) and its Pleistocene deposits have been interpreted in the classic Alpine chronology that recognizes four major glacial events (Günz-Mindel-Riss-Würm) and three interglacials. The Alps were repeatedly glaciated throughout the Pleistocene (Butzer 1971, Van Andel and Tzedakis 1996) and periglacial conditions dominated the region during episodes of Alpine glaciation. At times of maximum glaciation Vindija was within 100 km of mountain glaciers located in the Karavanki Mountains to the northeast (Malez et al 1984). Cryoturbated sediments and a large ice-wedge in strata dating to the Würm Glacial (Complexes G and F, and K) attest to the extreme cold of the periglacial environment in the vicinity of Vindija during glacial events.

Despite the sedimentary evidence of extreme cold, a recent revision of the faunal remains from Vindija (Brajković 2005) has reduced the numbers or removed entirely certain cold weather species from the faunal inventory (saiga antelope, wooly rhino, and reindeer). The revised composition of faunal communities present in the

Paleolithic strata suggest that the area was dominated by temperate woodland (Brajković 2005) through the Late Paleolithic with some variation through time as temperatures alternated between warmer and cooler phases.

Paleoenvironmental data acquired from ice cores and pollen records in continental sediments supports the contention that the area in the vicinity of Vindija may have acted as refugia for temperate tree species during glacial episodes (Van Andel and Tzedakis 1996). Temperate tree species, largely mixed oaks, would have spread from these centers during interglacials periods or the warmer stadials, allowing for the colonization of the southern foothills of the Alps by pine and spruce. Palynological analysis of samples from Vindija indicates that species of pine were present in the area during the deposition of sediments comprising Complexes G and F (Paunović et al 2001 and references therein). There is also indication of vegetation from open landscapes in several of the stratigraphic sub-divisions of Complex G.

At present only a general picture of the paleoenvironment for this region is known. Additional data and further study of faunal assemblages, taphonomy, and the deposition and weathering of cave sediments, and especially those from Vindija, are necessary in order to refine the paleoenvironmental record of the southeastern Alpine foothills.

Chapter 3: History of Investigations at Vindija Cave

This sub-Alpine region of south-central Europe has produced skeletal remains of archaic and modern humans and their associated material culture from stratified cave and rockshelter contexts and provides a unique opportunity to investigate human biological and cultural evolution from a regional perspective (Smith 1982, 1984, Smith and Raynard 1980, Frayer et al 1993). Important sites for human evolutionary studies in this region are Krapina, Velika Pećina, and Veternica. The interpretation of the Middle and Upper Paleolithic deposits at Vindija has, however, been a source of debate (Zilhão and d'Errico 1999b, Karavanić and Smith 2000, Straus 1999). The stone and bone tool assemblage and fossil human remains of Level G1 are of particular interest to the Middle to Upper Paleolithic Transition in Central Europe and may provide valuable evidence regarding the cultural and biological evolution and/or interactions that took place in this region of Europe.

3.1 History of Excavations

Early Excavations

The first archaeological excavations at Vindija were conducted by Stjepan Vuković beginning in 1928, continuing on and off for more than three decades. Upon his first visit to the site, Vuković observed subsurface disturbances within the cave, presumably the work of relic collectors reported to have acquired prehistoric artifacts from this location (Vuković 1935). Vuković excavated trenches both in front of and inside the cave where he identified seven stratigraphic units in three profiles (Vuković

1949). Mousterian and Upper Paleolithic stone tools were collected at this time, as well as Neolithic, Roman, and Medieval artifacts from the upper levels.

All the archaeological materials recovered during these excavations are currently housed at the Varaždin City Museum in Varaždin, Croatia. Vuković's methods and analyses of the cultural materials are presented in several regional publications (Vuković 1935, 1949, 1950, 1953, 1954, 1970). The Paleolithic materials from these early excavations have not received any further analysis since that time. At present the stratigraphy documented by Vuković has not been correlated to the stratigraphic profile observed in later investigations (see below). For this reason, in addition to constraints of time and location, none of the material collected during Vuković's excavations are included in the present study.

1974-1986 Excavations

Extensive excavations at Vindija under the direction of Mirko Malez of the Institute for Quaternary Paleontology and Geology, Zagreb, began in 1974 and continued every summer after, ending in 1986. Excavation was carried out by natural levels, vertically, by block, beginning in the front of the cave and progressing to the rear and sides, thus exposing significant portions of the stratigraphic sequence in profile**.** Two witness profiles were left during these excavations and can be seen in the cave today, Pyramid I at the North entrance of the cave (Figure 3.1) and Pyramid III (Figure 3.2) along the north wall of the cave approximately 10 meters east of Pyramid I.

Thirteen stratigraphic units were identified among the cave deposits (Figure 3.3) during Malez's excavations. Levels A, B, and, C are Holocene-aged and contain a small amount of early Neolithic, Bronze Age, Roman, and Medieval artifacts. The remainder of the sediments, Levels D-M, were deposited during the Pleistocene. The floor of the cave was exposed in some areas and is overlain with boulders and brecia comprising non-cultural Level N.

Three of the Pleistocene levels were further sub-divided into Complex F (Levels Fg, Fs, Fd, Fd/d), Complex G (Levels G1, G2, G3, G4, G5), and Complex K (Levels K1, K2, K3). These divisions are based on macroscopically observed variation in the color, texture, and/or the presence of rubble within the sediments. The alterations made in stratigraphic nomenclature nor the variation in sedimentology are directly addressed by Malez and Rukavina (1979). It is not known at present if these differences in strata existed but were not documented prior to 1979, or if the 1977-1979 excavations revealed a new pattern in the sedimentation of these four complexes. Malez and Ullrich (1982:8) note that levels a-j that were identified during the 1974-1976 field seasons correspond to later levels in the following way, "d" = Level D, "e" = Level E, "f" = Complex F, "g" = Level G1, "h" = Level G3, "i"= Level G4, and "j" = Level G5. This indicates that the division of Complex G was retroactively applied to already excavated sediments.

Working within a cultural-historical paradigm, the goals of Malez's excavations were to generate a geostratigraphic record by which to investigate the paleoenvrionmental and paleoclimatic history of the region and to establish an archaeological sequence based on identifiable tool types. Excavation proceeded rapidly with minimal documentation and much contextual information has been lost as a result. Fauna, artifacts, and human remains from the Pleistocene deposits were labeled only with the stratigraphic unit from which the artifacts were recovered and no other spatial data were recorded. No anthropogenic features were identified during excavation or during the subsequent processing of material or sedimentological analysis. The stratigraphy, chronology, and the archaeological sequence are discussed below.

Figure 3.1 Pyramid I: Witness profile at the entrance of Vindija Cave.

Figure 3.2 Pyramid III: Witness profile along the north wall of the cave approximately 10 meters from the entrance.

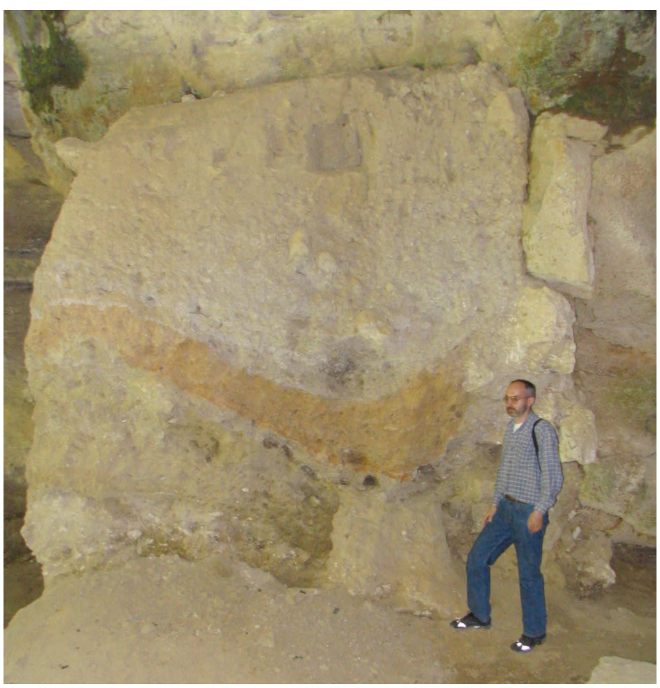
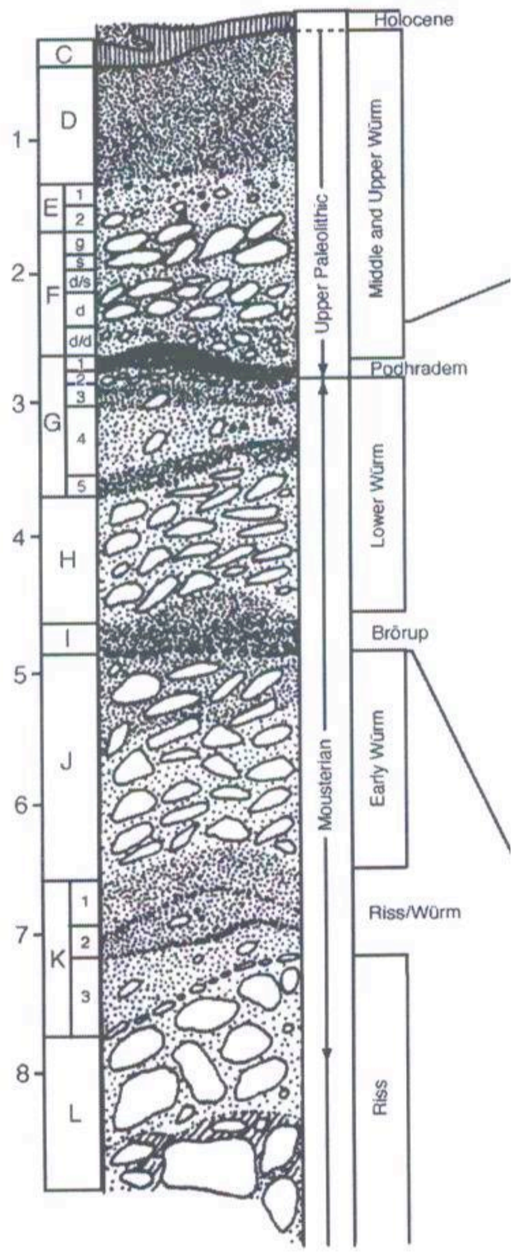


Figure 3.3 Profile of Pleistocene deposits (after Rukavina 1983).



3.2 Stratigraphy

The lithostratigraphy of the Vindija deposits is described in detail by Malez and Rukavina (1979) and Malez et al (1984) and is summarized here in Table 3.1. A schematized profile can be seen in Figure 3.3 (see also Ahern et al 2004 and Karavanić 1995 for summaries in English). As noted in Chapter 2, the Pleistocene deposits at Vindija span the Riss through the Würm Glacial periods, most likely beginning with Oxygen Isotope Stage (OIS) 5e in Level K. Complex G was deposited during OIS 3 (Paunović et al 2001), and the oxidation of iron in Level G1 suggests that it was deposited during a warm and humid period, most likely the Würm 2/3 interstadial.

Evidence of Post-Depositional Disturbances

Post-depositional disturbance of the Pleistocene sediments by cryoturbation was noted during the first field season (Malez 1975). Evidence of cryoturbation is documented in the front portion of the cave, near the center of the main hall and affecting portions of levels E, F, and G (Malez and Rukavina 1975). Figure 3.4 shows a profile of the cryoturbated sediments in the central portion of the main hall. In addition, an ice wedge was later observed in profile approximately 15 meters from the entrance of the cave and extending in depth from levels G5 to K (Malez et al 1984) but likely affecting the upper levels of Complex G and the lower levels of Complex F as well (Paunović et al 2001).

No other incidents of post-depositional disturbances to the sediments were documented during excavation. Malez does mention (Malez and Rukavina 1975,

1979) that in some places it was difficult to determine the boundaries of the different sedimentary units within Complexes F and G, likely due to the effects of post-depositional alterations to the sediments as result of cryoturbation. The effects that these disturbances had on the archaeological materials found within those complexes is noted by Malez:

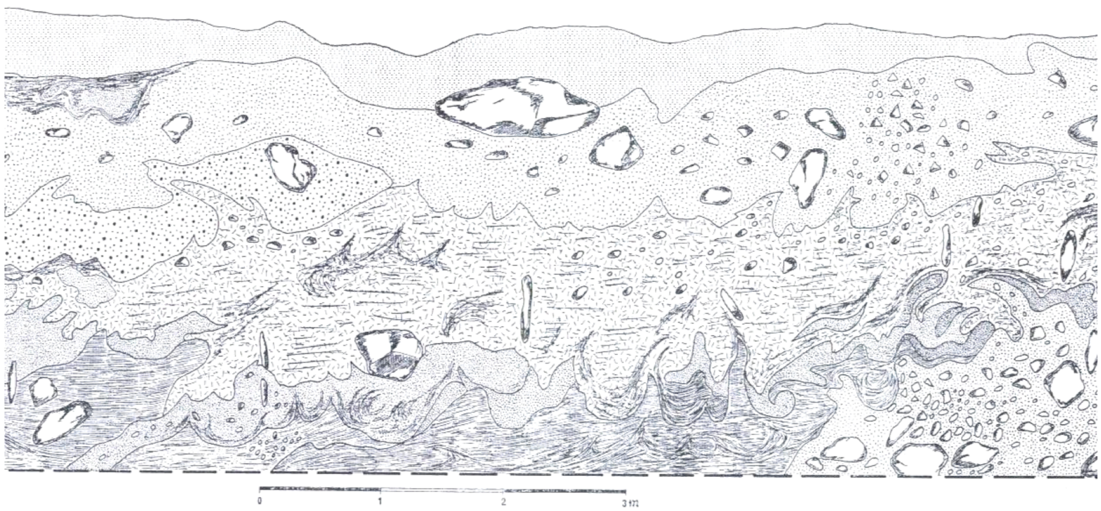
> "Fossils from Stratum G3 (end of Wurm II; Mousterian): 54 skeletal remains. Not all of the remains of this fossil group were secured directly from the hominid fossil level G3; some originate from higher (G1 = g, Fd/d/d, Fd) or lower beds (G5 = i, j, l) respectively. These fossils may, nevertheless, have originally lain precisely in the hominid level G3 and only secondarily arrived at their points of discovery as a result of the effects of cryoturbation." (Malez and Ullrich 1982:16) [Text translated from German by E.R. McGowan IV]

The degree to which post-depositional disturbances have affected the archaeological assemblages and possibly led to the mixing of materials from different cultural deposits or strata is an unresolved issue which relates directly to the question of Vindija and the Middle to Upper Paleolithic transition.

Table 3.1 Summary of the lithostratigraphy of the Pleistocene deposits of Vindija Cave (after Malez and Rukavina 1979).

LEVEL	SUB-LEVEL	DEPTH (cm)	MUNSELL COLOR	LITHOLOGY
D		50-150	10YR7/4	Fine sandy loess
E		< 60	5Y5/2 or 5Y6/1	Sand w/stones; pinches out in places
F		30-150	n/a	Sandy
	Fg	n/a	N6	Sandy w/cryoclastic particles
	Fs	n/a	N7	Sandy w/cryoclastic particles, rubble, and blocks
	Fs/d	8 cm	N4	Clay
	Fd	n/a	N5 & 5Y4/4	Sandy w/cryoclastic particles and rubble
	Fd/d	n/a	n/a	Alternating 2-5 cm lenses of gray and green sand
G		60-150	n/a	Sandy w/corroded detritus and rubble
	G1	8-20	5YR4/4	Clay
	G2	1-30	N6	Clay; not present in all of the cave
	G3	10-30	10Y5/4	Sandy, loess-like sediment
	G4	40	10Y4/2	Loess w/ lenses of light and dark green
	G5	15-30	10YR5/4	Reddish-brown sandy sediment
H	n/a	100-200	10Y6/2 & 5Y8/4	Sandy sediment w/ sharp-edged rubble and cryoclastic particles
I	n/a	30-100	5YR4/4	Reddish-brown sandy sediment w/ detritus
J	n/a	100-200	5Y5/2	Sandy sediment w/detritus
K		75-85	n/a	n/a
	K1	n/a	5YR3/4	Sandy
	K2	n/a	5YR2/2	Sandy
	K3	n/a	10YR4/2	Sandy
L	n/a	130-220	n/a	Brecia w/boulders

Figure 3.4 Cryoturbation in profile at Vindija Cave (after Malez and Rukavina 1975). This profile represents the upper three meters of Pleistocene strata prior to the subdivision of complexes F and G. The profile is located in the center of the cave approximately 15 meters from the cave opening.



3.3 Chronology

Radiometric dates obtained from the Paleolithic strata at Vindija depict a complex stratigraphic situation. All published radiometric dates are summarized in Table 3.2 (conventional radiocarbon and AMS) and Table 3.3 (other radiometric methods). While the relative ages of the Paleolithic strata has been considered a given, that is, that older deposits are overlain by younger deposits, the application of radiocarbon and other dating techniques has demonstrated incongruities among the deposits at Vindija (Wild et al 2001), particularly in Complex G and underlying strata.

Based on current radiometric evidence Level E correlates to the Last Glacial Maximum approximately 18,000 rcybp and this age determination is in agreement with the sedimentological characteristics of this strata. Recent AMS dates obtained from two Neandertal specimens from Level G1 (Vi-207 and Vi-208) date this level to approximately 33,000 rcybp (Higham et al 2006) and are in agreement with two of the four Uranium series determinations from this level (32,800 +/-1900 rcybp and 33,100 +/-800 calendar years before present) as well as a previous radiocarbon determination made from an *Ursus spelaeus* bone (33,000 +/-400 rcybp).

The remaining radiocarbon dates obtained from samples from Level G1 range from 18,000 rcybp to 46,000 rcybp. While some of the dates may be argued to be more reliable than others they have all been presented here only to illustrate the challenges that are faced in interpreting the stratigraphy of this site. For example, the small amount of datable collagen obtained from the Neandertal samples Vi-207 and Vi-208 may have led to younger AMS ages for these same samples in a previous dating attempt and those obtained more recently using an ultra-filtration method probably more accurately represent the actual age of these remains (Higham et al 2006, Smith et al 1999). Poor preservation of collagen could also be the explanation for aberrant radiocarbon ages of 18,280 +/-440 and 46,800 +2300/-1800 obtained from other samples from this same level. Based on this evidence, however, the possibility that materials of different ages are mixed in this level cannot be discounted.

Direct dating by accelerator mass spectrometry of two hominid specimens from Level G3 are in agreement at two standard deviations and places that strata at approximately 34,000-42,000 rcybp. Radiocarbon dates obtained from the underlying

Levels H, I, and J are younger than that for G3 (Table 3.2). Uranium series dates on cave bear bones from the boundaries of Levels H/I and Levels I/J and from Level J are probably more accurate indicators of the ages of these deposits. Dates obtained for Level H are, however, younger than those obtained by the same method from faunal samples from stratigraphically higher, and theoretically younger, Levels G1 and G3. It is possible that these inverted dates indicate that materials from younger deposits have been mixed with older deposits in some strata. Other explanations for incongruous ages observed through the profile include poor preservation of datable collagen (Karavanić et al 1998), differential pretreatment of samples (e.g. Higham et al 2006 *contra* Smith et al 1999), and/or the fluctuation of atmospheric carbon between 30,000-50,000 BP (Richards and Beck 2001, Conard and Bolus 2003).

Table 3.2 Radiocarbon (conventional) and accelerator mass spectrometry dates from Vindija Cave. Dates are given in uncalibrated, radiocarbon years before present (rcybp).

LEVEL	SAMPLE	DATE (rcybp)	METHOD	LAB No.	REFERENCES
E	*Ursus spelaeus*	18,500+/-300	C-14	Z-2447	Obelić et al 1994
F	Charcoal	24,000+/-3300	C-14	Z-612	Srdoč et al 1984
F	Charcoal	29,700+/-2000	C-14	Z-613	Srdoč et al 1984
Fd	Charcoal	27,000+/-600	C-14	Z-551	Srdoč et al 1979
Fd/d	*Ursus spelaeus*	26,600+/-930	C-14	Z-2433	Obelić et al 1994
G1	*Ursus spelaeus*	18,280+/-440	C-14	Z-2432	Obelić et al 1994
G1	*Ursus spelaeus*	33,000+/-400	C-14	ETH-12714	Karavanić 1995
G1	*Ursus spelaeus*	46,800 +2300/-1800	AMS	VERA-1428	Wild et al 2001
G1	Hominid Vi-207	29,080+/-400	AMS	OxA-8296	Smith et al 1999
G1	Hominid Vi-207	29,100+/-360	AMS	OxA-2082-10	Higham et al 2006
G1	Hominid Vi-207	32,400+/-1800	AMS	OxA-2089-07	Higham et al 2006
G1	Hominid Vi-208	28,020+/-360	AMS	OxA-8295	Smith et al 1999
G1	Hominid Vi-208	29,200+/-360	AMS	OxA-2082-09	Higham et al 2006
G1	Hominid Vi-208	32,400+/-800	AMS	OxA-2089-06	Higham et al 2006
G1	Hominid Vi-208	31,390+/-220	AMS	OxA-2094-10	Higham et al 2006
G3	Hominid Vi-80	38,310+/-2130	AMS	Unknown	Serre et al 2004
G3	Hominid Vi-203	>42,000	AMS	Ua-13837	Krings et al 2000
H	*Ursus spelaeus*	33,400 +2000/-1600	C-14	VRI-1125	Wild et al 2001
I	*Ursus spelaeus*	37,000+/-600	AMS	VERA-0109	Wild et al 2001
J	*Ursus spelaeus*	34,700+/-500	AMS	VERA-0105	Wild et al 2001

Table 3.3 Other radiometric dates from Vindija Cave. All dates are in calendar years before present.

LEVEL	SAMPLE	DATE	METHOD	REFERENCE
G1	*Ursus spelaeus*	32,800+/-1900	U/Th	Wild et al 2001
G1	*Ursus spelaeus*	33,100+/-800	U/Th	Wild et al 2001
G1	*Ursus spelaeus*	27,900+/-100	U/Th	Wild et al 2001
G3	*Ursus spelaeus*	41,000 +1000/-900	U/Th	Wild et al 2001
G3	*Ursus spelaeus*	42,400+/-4300	AAR	Malez et al 1984
H	*Ursus spelaeus*	29,100+/-1000	U/Th	Wild et al 2001
H	*Ursus spelaeus*	36,500+/-1600	U/Th	Wild et al 2001
H/I	*Ursus spelaeus*	88,200+/-2300	U/Th	Wild et al 2001
I/J	*Ursus spelaeus*	168,300 +8700/-8400	U/Th	Wild et al 2001
J	*Ursus spelaeus*	156,300 +2100/-1800	U/Th	Wild et al 2001
J	*Ursus spelaeus*	158,600 +8100/-7900	U/Th	Wild et al 2001
J	*Ursus spelaeus*	196,000 +20000/-15000	U/Th	Wild et al 2001
K	*Ursus spelaeus*	150,400 +16200/-13200	U/Th	Wild et al 2001
K	*Ursus spelaeus*	159,300 +10000/-9500	U/Th	Wild et al 2001
K	*Ursus spelaeus*	212,200 +16700/-12800	U/Th	Wild et al 2001

3.4 The Archaeological Sequence

The stratified deposits at Vindija contain archaeological materials from both the Middle and Upper Paleolithic time periods. Assemblages are composed of chipped stone, bone tools and ornaments, and the skeletal remains of both archaic and modern humans. A reevaluation of the stone tool assemblages is not the goal of this thesis and therefore the cultural attributions for each level as determined by previous research are summarized from the available literature (Table 3.4). Cultural determination of each level is based on the presence of formal tool types within the assemblage (Bordes 1961, de Sonneville-Bordes and Perrot 1953 for the Middle and Upper Paleolithic levels respectively) and/or the relative position of each level within the stratigraphy (Karavanić 1995, Karavanić and Smith 1998).

Table 3.4 Archaeological sequence from Vindija Cave.

LEVEL	CULTURAL DETERMINATION	REFERENCES
D	Epigravettian	Karavanić 1995, Janković et al 2006
E	Epigravettian	Karavanić 1995, Janković et al 2006
Fg	Epigravettian	Karavanić 1995, Janković et al 2006
Fs	Epigravettian	Karavanić1995, Janković et al 2006
Fd/s	Epigravettian	Karavanić 1995, Janković et al 2006
Fd	Undetermined	Karavanić 1995
Fd/d	Aurignacian	Karavanić 1995, Janković et al 2006
G/F	Aurignacian	Karavanić 1995
G1	Undetermined	Karavanić 1995, Karavanić & Smith 1998, Janković et al 2006
G2	Mousterian	Karavanić & Smith 1998
G3	Mousterian	Karavanić & Smith 1998, Ahern et al 2004
G4 - L	Mousterian	Malez & Ullrich 1982

Chipped Stone Assemblage

The chipped stone assemblages from Levels D through G3 have been studied from a typological (Karavanić 1995, Karavanić & Smith 1998, Karavanić 1994) and technological (Ahern et al 2004, Blaser et al 2002) perspective. Levels D and E and the upper levels of Complex F contain a blade based technology attributed by Karavanić (1995, Janković 2006) to the Epigravettian. Tools account for between 9.8% and 47.9% of the chipped stone assemblage from these Levels and include blades with continuous retouch, burins, and endscrapers on blades. Side scrapers are also present in these assemblages, especially at the interface of Level E and Complex F (Level E/F).

The chipped stone assemblages from the lower portion of Complex F, Levels Fd and Fd/d, also contain continuously retouched blades, burins, and endscrapers on blades that indicate an Upper Paleolithic origin. The presence in these assemblages of denticulate and notched pieces made on flakes, along with stone tools typical of both the Aurignacian and the Gravettian does not allow for a firm designation (Karavanić 1995). While the chipped stone assemblage itself is ambiguous, Level Fd/d is attributed to the Aurignacian due to the presence of Mladeč type massive base bone points among the cultural inventory.

The chipped stone assemblage from Level G1 and the interface of Complex F and Complex G (Level G/F) contain a mixture of Upper Paleolithic technology and tool types such as retouched blades, burins, and endscrapers with side scrapers common in the Mousterian. A bifacial leaf point typical of the Szeletian further complicates the cultural designation of these levels. Additional leaf points are found in the underlying Levels G2 and G3, both attributed to the terminal Mousterian and both containing a flake-based chipped stone technology.

Typological analyses are beneficial for establishing a cultural sequence and for inter-site comparisons, as well as facilitating communications among researchers. Two significant issues limit the utility of this method at Vindija. First, the small number of formal tools in the assemblages from this site (the largest tool count is 45 in Level D) preclude the use of quantitative comparisons and relative frequencies that enable a cultural designation based on established standards (Bordes 1961). With such small assemblages the presence of only a few formal tools can potentially alter the typological classification of the assemblage. The fact that stone tool assemblages from Levels Fd, Fd/d, G/F, and G1 remain ambiguous with regard to cultural designation highlights this issue.

Second, the application of a typological framework based on the French Paleolithic may obscure the regional character of stone tool production and /or style. This is of considerable concern with regard to the Middle-Upper Paleolithic transition in central and southeastern Europe where evidence has accumulated that suggests a mosaic of cultural manifestations and stone tool industries leading up to and during the so-called transition (Brantingham et al 2004a). Many of these stone tool industries have yet to be firmly defined in terms of either typology or geography and a typological framework for the region is lacking at this time. It is not a surprise then that the very levels that remain typologically ambiguous at Vindija are those that span this culturally dynamic, but not yet well understood, period of time known as the Middle-Upper Paleolithic transition.

Lithic Materials

Lithic materials utilized in the production of stone tools at Vindija include quartz, quartzite, chert, tuff, basalt, and other unidentified siliceous rocks exhibiting patterns of concoidal fracture. Quartz is the most common chipped-stone material among the Mousterian assemblages and the amount of chert or other siliceous rocks increase in total proportion of the assemblages through the Upper Paleolithic levels (Blaser et al 2002). Lithic artifacts are made almost exclusively from materials available locally and were likely procured from the gravel deposits of the Drava River or from nearby secondary drainages (Kurtanjek and Marci 1990). Exceptions to this trend are specimens of a relatively high quality caramel colored chert present mostly in Level D but also seen in lower levels. This material is unidentified and its source is unknown, though the presence on some pieces of a limestone cortex-like rind coupled with the relatively unweathered condition of the stone suggests the possibility that this material may have been procured from a primary bedrock source rather than secondary river gravel deposits.

Bone Tools and Ornaments

Bone technology is represented in Epigravettian Levels D, E, Fs, and Fd/s by awl and awl fragments, sagaie and massive-base point fragments and a single tooth pendant (Level D). Additional massive-base point fragments were found in Levels Fd, Fd/d, and G1 and in Complexes F and G. Two complete massive-base points were found at the interface of Complexes F and G (labeled Fd/d+G1) and a complete split-based point was recovered from Level G1. A complete bear *bacculum* with incised rings was also found in Level G1.

Bone "buttons" were found throughout the Pleistocene levels. Though sometimes included in the inventory of cultural materials (e.g. Malez 1985), these distinctive objects are likely the result of natural processes such as trampling by cave bears. Similar objects have been found in European caves used heavily by *Ursus spelaeus* and while the possibility that they were manufactured by humans is not disproved, the most likely explanation is that they were generated by natural processes (Bahn 1983).

Human Remains

Human remains were recovered in Levels D, Fd, G1 and G3 (Malez 1978, Malez & Ullrich 1982). The skeletal inventory includes 45 cranial and postcranial bones of anatomically modern humans from Level D, 10 specimens of indistinct morphology from Complex F (Wolpoff et al 1981, Smith et al 1985), at least six Neandertal specimens from level G1, and 48 Neandertal cranial and postcranial remains from level G3.

With regard to skeletal morphology the specimens from Level G3 are diagnostically Neandertal and occupy an intermediate position between classic Central European Neandertals such as those at Krapina and early anatomically modern humans (Wolpoff et al 1981; Smith 1982, 1984, Malez et al 1980). These, along with the specimens and from Level G1, are described as "progressive" in terms of morphological attributes and demonstrate local evolution toward modern morphology.

3.5 The Cultural and Chronological Context of the Middle to Upper Paleolithic Transition in Central Europe

Traditionally, the Middle to Upper Paleolithic transition refers to the change in the archaeological record of Europe from flake-based Mousterian technological industries to an Upper Paleolithic blade-based technology. This change in the record coincides roughly with the appearance of anatomically modern humans into regions of the Eurasian continent that were, up to that point, occupied by Neandertal populations. Several models have been advanced to explain the relatively rapid replacement of Middle Paleolithic industries in Europe by the Aurignacian techno-complex between 40,000 – 30,000 BP and the nature of biological and cultural interactions between local Neandertal populations and AMH populations. The "Population-Dispersal" model (Mellars 1996) suggests that a relatively rapid, total replacement of Neandertals by Aurignacian-carrying AMH populations originating from the Near East occurred with no cultural or genetic exchanges. While the discovery that Neandertals are genetically distinct from modern Europeans (Krings et al 2000) would seem to support this model, total replacement is in reality, an unlikely scenario (Wolpoff et al 2001).

The Assimilation Model (Smith et al 2005) hypothesizes that in regions where there was sufficient temporal overlap, some degree of cultural and/or genetic exchange took place between Neandertal and AMH populations. The question of nature of interactions between these two populations is far from settled (d'Errico et al 1998, Zilhão and d'Errico 1999a, Mellars 1999, Churchill and Smith 2000, Miracle 1998, Carbonell and Vaquero 1998) and dependant largely on the timing of anatomically modern humans in these regions and the strength of the exclusive association of anatomically modern humans with the Aurignacian (Zilhão and d'Errico 1999b).

The identification of a Neandertal cranial fragment in a Châtelperronian level at Saint-Césaire (Hublin et al 1996) demonstrates that Neandertals were both capable of, and did develop Upper Paleolithic technology before the appearance of either AMH or the Aurignacian on the Iberian Peninsula (Zilhão and d'Errico 1999b, Churchill and Smith 2000). The same is likely true of the Uluzzian of Italy that also has roots in the local Mousterian, but pre-dates the arrival of anatomically modern humans in the region. Transitional industries combining both Upper and Middle Paleolithic elements are well documented in other regions of Europe as well (Brantingham et al 2004a) and it appears that the Upper Paleolithic technology may have already been in progress by the time anatomically modern humans arrived. Few fossil remains have been found in direct association with early Aurignacian assemblages making the unequivocal attribution of the earliest Aurignacian to a biological population problematic. The earliest evidence of AMH in Europe occurs in Romania at Pestera cu Oase and is AMS dated at 34-36,000 rcybp (Trinkaus et al 2003) but, unfortunately, was not found with any associated cultural materials.

While AMH are generally associated with the Aurignacian, the relationship of the transitional industries to the earliest Aurignacian assemblages during the Initial Upper Paleolithic is unclear. Directly dated Neandertal remains from Vindija (Higham et al 2006) show that Neandertals persisted in some areas even after the appearance of anatomically modern humans. Given the current record it would appear that rather than a simple act of replacement, the Middle-Upper Paleolithic transition reflects a regionally variable process.

The Initial Upper Paleolithic in Central Europe

Two distinct Early Upper Paleolithic industries are currently known in Central Europe and several less-well defined industries may also exist. The Bohunician is found in Moravia and adds blade technology to a predominately Levallois Mousterian industry (Kozłowski 2004). No human remains have been found with these assemblages, all of which are open-air sites. This industry may be intrusive to the region, having originated in the Near East or elsewhere (Svoboda 2004, 2005).

The Szeletian is dated to approximately 41-35,000 BP and is characterized by a stone tool inventory composed of both Middle and Upper Paleolithic elements, the presence of bifacial leaf points, and employment of bone tool technology (Allsworth-Jones 1986). There are no substantial associations of Neandertals with Szeletian assemblages but the technological affinities to the preceding local Mousterian and the chronostratigraphic positions of the assemblages both strongly suggest that this industry was developed out of the local Mousterian. It is therefore, assumed to be generated by Neandertals.

The Szeletian and the Bohunician, as well as additional less-well defined or site-specific industries in Central Europe demonstrate a mosaic of industries on the cultural landscape of Central Europe during the time of the Middle-Upper Paleolithic transition. Further survey and research will determine if these are the result of functional variation within a single cultural group, or indeed represent the presence of multiple cultural entities in the region. Regardless of the explanation for this variability, data from Central Europe shows that Neandertal populations were generating Early Upper Paleolithic elements and industries prior to, and possibly after, the appearance of AMH in Europe.

Relevance of Vindija Cave to the Middle-Upper Paleolithic transition

Level G1 at Vindija contains an unusual grouping of cultural materials not seen at other locations dating to this time period. Stratigraphically, Level G1 is situated between Mousterian level G3 and Aurignacian level Fd/d. Neandertal bones have been directly dated by AMS to 33-34,000 rcybp and represent some of the latest Neandertals in Europe. The Neandertals remains are in stratigraphic association with a stone tool assemblage composed of both Upper and Middle Paleolithic types, including a bifacial leaf point made from a non-local lithic material, as well as bone tools typically associated with the Upper Paleolithic. The bone technology from Level G1 consists of Mladeč type bone points, a split-based bone point, as well as an incised bear *bacculum*. The stone tool assemblage is generally of an Upper Paleolithic character and the bone technology is suggestive of the Aurignacian (Karavanić 1995).

Despite the bone technology the attribution of Level G1 to the Aurignacian is problematic given that bifacial technology is not known to occur in the Aurignacian.

Bifacial leaf points of the Szeletian are considered by some to be evidence of continuity from the Middle Paleolithic in the middle Danube region (Svoboda 2004, 2005) and this may be evidenced also at Vindija where bifacial leaf points are present in the preceding Mousterian level, G3. The co-occurrence of bifacial leaf points and bone points, both split-based and Mladeč type is common in Szeletian sites (Svoboda 2004). Vindija is located at the margins of the known geographic range of the Szeletian though the AMS dates of 33-34,000 rcybp place it slightly outside the current age range of 35-41,000 rcybp (Allsworth-Jones 1986). Nevertheless, if Level G1 is, in fact, Szeletian it would be the first direct association of Neandertals with a transitional industry outside of France and the Châtelperronian.

Regardless of the cultural affiliation of Level G1, its significance for the Middle to Upper Paleolithic transition is considerable. The late-dated Neandertals demonstrates their persistence in the middle Danube region and opens the possibility of temporal overlap with anatomically modern humans. The Neandertal association with bone technology that has been traditionally associated with anatomically modern humans and the Aurignacian calls into question the strict association of Aurignacian with AMH and has ramifications for the interpretation of other Early Upper Paleolithic sites for which no human remains were found. Finally, the association of Neandertals with a transitional industry would provide firm evidence of continuity through the Middle--Upper Paleolithic transition in this region.

Chapter 4: Research Strategy and Methods

The archaeological record is a contemporary record (Binford 1975, 1977a) that has been subject to a variety of transformations by both cultural and natural processes (Schiffer 1976, 1987) since the time of its initial deposit. Though learning about human behavior is the goal of anthropological archaeology, it is essential that the contextual integrity of assemblages and sites be thoroughly evaluated before proceeding to behavioral inferences derived from those materials. The spatial and temporal relationships of artifacts, features, and sites are fundamental to the generation of knowledge of human behavior in the past. Critical assessment of the context of finds is crucial to the interpretation of any site or aggregate of artifacts. The stratified deposits at Vindija are no exception, however, thus far, research aimed at contextual analysis has not been forthcoming.

Interpretive problems resulting from the *a priori* assumption that aggregates of artifacts in stratigraphic association necessarily belong together are readily seen in levels Fd/d, G1, G2, and G3 at Vindija. These assemblages are typologically and technologically "mixed" and a clear designation of cultural affinity is not necessarily possible (Karavanić 1995, Karavanić and Smith 1998). It remains uncertain as to what significance these potentially very informative materials may have on the understanding of cultural dynamics during the Middle to Upper Paleolithic Transition. Do the "mixed" assemblages from these levels represent as yet poorly defined transitional industries demonstrating continuity from the local Mousterian in this region? Or have materials of different cultural manifestations and ages been brought into stratigraphic association by post-depositional processes? Evaluation of the stratigraphic integrity of these deposits will provide critical insight into the degree of resolution provided by the assemblages in question and in so doing will provide a basis on which meaningful and justifiable behavioral inferences may be generated.

This study utilizes refitting of chipped stone from the Upper and Middle Paleolithic levels of Vindija to test the stratigraphic integrity of these deposits. The central question addressed by this thesis is whether or not there is evidence of post-depositional vertical movement of cultural materials. Secondly, if so, to what extent has post-depositional movement of artifacts affected the composition of the chipped stone assemblages?

4.1 Matters of Discreetness, Cohesion, and Resolution

Originating from a concern with the context of archaeological finds, several scholars have noted that historically, and particularly with regard to the stratified deposits of caves and rockshelters, there exists a tendency to view geologically defined stratigraphic units as relatively undisturbed sealed containers for cultural materials (Villa 1982:276, Hofman 1992a: 3, Straus 1979:335, Butzer 1981:179, Hassan 1987:6). Artifacts collected from within the same geological strata are frequently grouped into a single assemblage for analytical purposes and presumed to represent cohesive remains of a discreet cultural entity. By grouping aggregates of artifacts deposited over a geologically defined and bounded period, this practice obscures variability in the archeological record and limits the temporal and spatial resolution with which these assemblages may be applied to the study of past human behavior.

Two issues of concern regarding this practice, and relating specifically to the interpretation of the assemblages from the Paleolithic levels of Vindija are the palimpsest nature of archaeological deposits and the documented occurrence of the migration of artifacts through both archaeological and geological deposits.

Palimpsests

The accumulation and formation of geological strata in caves and rockshelters is a time dependent process where rates of sedimentation vary according to the sources, frequency, and intensity of episodes of deposition and erosion. Likewise, the accumulation of material culture within geological strata is dependent on the frequency and intensity of site occupation and use. In Bailey's terms (2007), the archaeological assemblages from Vindija are "cumulative palimpsests," materials deposited as a result of successive occupations of the cave by prehistoric people where each deposit is superimposed over the previous deposits and materials become "mixed together as to blur the patterning peculiar to each individual episode" (Bailey 2007: 204). Though the material remains of multiple discreet episodes of occupation are present in such deposits, the resolution at which they may be meaningfully interpreted may become compromised by a loss of stratigraphic and spatial details due to post-depositional processes.

The cohesion of such assemblages remains problematic and is essentially an issue of scale. Only in rare cases do archaeological deposits represent a "moment in time," though notable exceptions are seen at sites such as Pincevent (Leroi-Gourhan and Brézillion 1972) and Meer II (Cahen and Keeley 1980, Van Noten et al 1980). Rather, the accumulation of artifacts, even on an identifiable living surface, potentially represents the material remains of multiple episodes of occupation and/or activity, and, in absence of multiple lines of evidence to the contrary, cannot be assumed to be the result of cohesive cultural expressions (Bordes 1975). This issue is especially relevant to the interpretation of "transitional" industries of the Initial Upper Paleolithic in Central Europe, both in chronostratigraphic and behavioral terms.

Certainly, as chronological and geographic scales increase the concept of materials that "belong" together becomes more general, and the time-scale of a few thousand or even ten thousand years as represented by the accumulation of sediments may be insignificant to broad reaching research questions using temporally and spatially course-grained data. Archaeological materials are, in that sense, never without analytical value regardless of their degree to which they may be considered discreet. The scale at which they are capable of being meaningfully employed must be evaluated and accommodated.

Vertical Movement

A second issue pertaining to the cohesion and resolution of archaeological assemblages is the migration of artifacts away from the original location of deposit in the archaeological context. Experimental research (Villa and Courtin 1983, Cahen and Moeyersons 1977, Moeyersons 1978, Stockton 1973, Gifford-Gonzalez et al 1985) and specific case studies (Villa 1982, 1983, Hofman 1986, 1992b, Cahen and

Moeyersons 1977, Cahen et al 1979, Van Noten et al 1980, Petraglia 1992, Straus et al 1988, Siiriainen 1977, Jodry 1992) have demonstrated that artifacts routinely migrate both vertically and laterally as a result of post-depositional processes. Artifact and artifact clusters brought into a secondary depositional context by post-depositional processes are not necessarily subject to a lack of resolution as exemplified by sites such as Meer II (Cahen and Keeley 1980) and Verberie (Audouze and Enloe 1997). Assemblages from stratified deposits offer a far more complex situation, especially when no sterile levels separate cultural deposits. Further, the vertical displacement of artifacts through seemingly undisturbed strata with clear delineations is documented largely from the application of refitting analysis (Villa 1982, 1983).

The potential for artifacts to migrate across stratigraphic breaks has significant implications for the cohesion of assemblages collected using geological boundaries as cultural dividers, as is the case at Vindija. The use of aggregates of artifacts from geological strata assumed, but not demonstrated, to represent a cohesive cultural expression, is problematic when the palimpsest nature of the archaeological record and the material evidence of the routine migration of artifacts from their location of deposit are taken into consideration. These issues relate directly to the interpretation of cultural material from Vindija where aggregates of artifacts grouped by geological strata are the *only* units of analysis possible. The question remains, at what scale is it appropriate to make behavioral inferences from the material remains at Vindija?

4.2 Post-depositional Processes and Site Formation at Vindija Cave

Cave deposits provide a wealth of information relating to Paleolithic lifeways and, due to the fact that caves often contain stratified deposits, changes in those lifeways through time. Caves are also complex depositional settings subject to a wide variety of natural processes that may alter sediments (and artifacts contained within those sediments) in many ways, both macroscopically observable and not (Farrand 2001a). Even at the least disturbed sites human behavior is not reflected directly in the associations and patterning of materials in the archaeological record. Many cultural and natural processes can lead to association of artifacts and patterning in archaeological materials that may either obscure or mimic those patterns generated as the result of human action (Wood and Johnson 1978).

As noted in Chapter 3, during glacial episodes periglacial conditions were prevalent in the vicinity of Vindija. In such a setting alteration and/or disturbance of cave deposits that may occur as the result of cycles of freezing and thawing include ice-wedging, cryoturbation, and frost weathering (Wood and Johnson 1978; Laville et al 1980; Farrand 2001b, Rapp and Hill 2006). Each of these have been observed among the Vindija deposits though the effects that these factors may or may not have had on the archaeological assemblages has not yet been systematically evaluated.

Though all sources of post-depositional alterations are important and worth investigating, only cryoturbation and bioturbation (specifically the implied disturbances by cave bears) are addressed here as each of these have been suggested as an explanation for "mixed" assemblages of Levels Fd and Fd/d (Karavanić 1995:

17) and particularly for the unusual association of artifacts in Level G1 (d'Errico et al 1998: S2, Zilhão and D'Errico 1999a: 355).

Cryoturbation

Cryoturbation is documented at Vindija (Malez and Rukavina 1975, Paunović et al 2001), although the precise location of the disturbed sediments is not available in published literature and there remains some disagreement over the relationship of the cultural materials to these disturbed sediments. The displacement of archaeological materials by cryoturbation is noted by Malez who writes that though they had been recovered from other levels (G1, Fd/Fd/d, Fd, G5) the original location of "some" of the human skeletal remains was Level G3 and that they were post-depositionally "moved to secondary levels by cryoturbation occurring inside the sediment complex F and G, primarily near the cave entrance" (Malez 1985:232, see also Malez and Ullrich 1982:16).

Bioturbation

Ursus spelaeus is the dominant taxon in all Pleistocene-aged levels of Vindija (Paunović 1987, Paunović et al 2001). Based on the comparison of mortality profiles taken from archaeological assemblages to those from strictly paleontological assemblages, Miracle (1991) argues that at Vindija and other Paleolithic cave sites in the region, the accumulation of cave bear bones resulted from natural deaths during hibernation and is not related to use of the cave by humans (see also Gargett 1996:41). It is suggested that such sites are best interpreted as cave bear dens, having been occupied only occasionally by humans.

The degree of disturbance that repeated use of the cave for hibernation by *Ursus spelaeus* might have had on the sediments and archaeological materials at Vindija has not yet been investigated. Modern bears have been observed removing large amounts of debris and sediment in the construction of sleeping areas (Rogers 1981, 1987) and these behaviors are reasonably extended to Pleistocene ursids (Gargett 1996; Kurten 1976; Stiner et al 1996). In addition to the horizontal and vertical rearrangement of sediment and archaeological materials during preparation of sleeping areas, movement of *Ursus spelaeus* within the cave may have led to artifacts on or near the cave floor being broken and/or vertically displaced by trampling, especially if the rate of sedimentation is low. Trampling by cave bears is one possible explanation for the fragmentary state of the human skeletal remains from Levels G1 and G3 at Vindija and is likely the cause of the surface damage present on the majority of skeletal fragments (Malez 1985, Malez and Ullrich 1982).

Additional research will provide insight on the taphonomy and history of post-depositional alterations to the archaeological deposits. At this time, the specific ways in which cryoturbation, *Ursus spelaeus,* and other natural processes have contributed to site formation at Vindija remains an open question.

4.3 Refitting in Archaeology

Refitting is an analytical technique that refers to the piecing together of artifacts that were once attached. It is a relatively simple though time-consuming technique that can be applied to a wide variety of materials and analytical and interpretive issues.

The refitting of chipped stone can be used in archaeology to address issues of technology (Dmochowski 2003, Škrdla 2003, Conard and Adler 1997), spatial organization (Cahen and Keeley 1980), and site formation processes (Villa 1982,1983 Audouze and Enloe 1997, Hofman 1986, 1992, Hofman and Enloe 1992, Cziezla et al 1990, Morin et al 2005, Morrow 1996, de Loecker et al 2003, Van Noten et al 1980, Jodry 1992). Refitting is useful in behavioral studies. For example, the fitting together of a core and its associated blank removals allows not only for the investigation of spatial distribution of a specific activity on a site, but additionally, analysis of the specific actions and decisions made during the reduction/production of stone tools provides critical insight into the cognition and technological goals of prehistoric flint knappers.

Refitting is especially useful as a method by which to evaluate the contextual integrity of archaeological deposits. At the Lower Paleolithic site of Terra Amata in the south of France refitting analysis demonstrated the vertical displacement of artifacts from what appeared during excavation to be superimposed living floors (Villa 1982, 1983). Evidence generated by refitting analysis was central to the revised interpretation of the site and the recognition that these materials were not in primary context, but rather had been brought into association by post-depositional processes. Villa's work is a classic example of the utility of refitting for assessing the stratigraphic integrity of stratified sites and underscores the importance of contextual analysis to a justified and more accurate inference of human behavior.

Similarly, the stratigraphic integrity and chronological resolution of the stratified cave deposits at Saint-Césaire were recently tested by the refitting of faunal materials from the Middle and Early Upper Paleolithic strata (Morin et al 2005). This site has been integral in establishing the chronology and cultural stratigraphy of southwest France, and particularly significant to understanding the spatial and temporal relationships of the Châtelperronian and Aurignacian industries. Saint-Césaire was the first site to reveal an association of Neandertals with the Châtelperronian industry (Hublin et al 1996) further complicating the interpretation of cultural and biological relations during the Early Upper Paleolithic. The question of mixing of deposits by cryoturbation and other post-depositional processes has led to skepticism over the integrity of the EUP strata.

The majority of refits were found to occur from within the same level at Saint-Césaire while between level refits were quite low at only 1.2% of the total number of refit sets. Morin and colleagues conclude that mixing of deposits at Saint-Césaire by post-depositional processes has been minimal and the stratigraphic integrity of the archaeological assemblages has not been appreciably compromised (2005).

4.4 Refitting Vindija Cave: Methods and Materials

This study focused on the chipped stone assemblages from Pleistocene levels D-L of Vindija. All non-quartz chipped-stone artifacts with known vertical provenience (n=1276) were included in the refitting analysis. The term "refitted artifacts" refers to two or more artifacts that articulate directly to form a more complete artifact. Articulation may occur either at the site of a flake scar where the ventral face and dorsal face of two artifacts fits together (Type 1, see below), or, at the location of a break where two fragments of conjoin to form a single artifact (Type 3, see below).

As the goal of this thesis is to investigate the stratigraphic integrity of the archaeological assemblages equal time and effort was given to inter-level and intra-level refits. All artifacts utilized in this study were grouped by lithic material type regardless of their level designation. These materials were identified macroscopically and consisted predominately of chert, tuff, quartzite, and basalt. Divisions within these material categories were subsequently made where appropriate on the grounds of macroscopically observed differences in color, texture, cortex, inclusions, etc. Groups were of manageable size with no single lithic material category containing more than 50 artifacts. Material groups were imposed for the sole purpose of increasing efficiency and were not adhered to rigidly. Individual artifacts were frequently re-grouped when close examination determined them to be more similar to another group and groups were occasionally collapsed as a result.

Working within each material category, each artifact was systematically attempted to refit to every other artifact within that same group. In the case that artifacts were found to refit together, the newly formed, and more complete piece composed of the refitted artifacts, was systematically attempted to refit to each remaining artifact within the same lithic material category.

Refit Sets

"Refit Sets" refers to two or more artifacts that refit together to form a more complete piece. Refit sets may consist of either ventral-dorsal articulations, representing artifacts separated as the result of the process of reduction, (Type 1, see below) or, broken artifacts that conjoin at the location of the break (Type 3, see below). Metric attributes recorded for the reconstructed artifact for each refit set include weight in grams and length and width in centimeters (see Appendix A).

Five additional sets of refitting materials (Refit Sets 30-34) were identified among the *non-chipped stone assemblage* of Vindija. These include four sets of refitted cobble fragments separated by natural processes (e.g. freeze-thaw) and exhibit no evidence of cultural modifications (Refit Sets 30-33). The fifth set is composed of conjoining proximal and medial fragments of a bone point (Refit Set 34). Descriptions of the non-chipped stone refit sets can be found in Appendix B. None of these five non-chipped stone refit sets are included in any statistical analyses or artifact counts.

Refit Types

In an effort to standardize the language of refitting analyses Cziesla (1990:3) encourages that distinction be made between three types of chipped stone refits:

1.) artifacts separated as the result of reduction

2.) artifacts separated as a result of reshaping or resharpening of an objective piece

3.) artifacts broken either by cultural or natural processes

Following Cziesla (1990) the 29 Refit Sets from Vindija are classified as either Type 1: the result of reduction process or Type 3: broken artifacts that conjoin at the location of their break. Figure 4.1 shows a microblade refitted to the core from which it was removed and is an example of a Type 1 refit (Refit Set 6). A Type 3 refit is shown in Figure 4.2 where two bilaterally retouched blade fragments conjoin to form a nearly complete bilaterally retouched blade (Refit Set 26).

In two cases (Refit Set 7 and Refit Set 18) two artifacts conjoin to form a complete or nearly complete flake to which a second flake is refit in a ventral-dorsal articulation (Figure 4.3). These Refit Sets are included with Type1 refits.

Each of Cziesla's three types of refits are informative with regard to contextual analysis because the spatial and vertical relationship of refitted artifacts which were at one point strictly contemporaneous is significant line of evidence by which to investigate post-depositional dynamics of archaeological deposits. Those artifacts that were separated as the result of the production and/or modification of stone tools are additionally informative with regard to human behavior as these provide evidence of specific activities performed at the site as well as the spatial relationship of those activities within the site.

Metric and Non-Metric Attributes and Analysis

Table 4.1 shows the metric and non-metric attributes recorded for the entire chipped stone assemblage (n=1276), including the 64 individual artifacts comprising the 29 Refit Sets. Metric attributes include weight in tenths of grams measured with an Ohaus Scout Pro 2000g digital scale and length and width in millimeters measured with SPi 2000 dial calipers. Length was measured following Andrefsky (1998: 98, Figure 5.8a and 5.8c) and is the maximum distance of the distal end of the flake from a line perpendicular to the platform. Width was measured at a point approximately one-half of the maximum length of the flake (Andrefsky1998: 99, Figure 5.9b).

The differential ease with which artifacts may move vertically due to weight and shape was accounted for by the calculation of a weight/size ratio for each of the refitted artifacts. This size ratio was obtained by dividing an artifact’s weight by the larger value of either length or width.

Table 4.1 Metric and non-metric attributes recorded for the Vindija Cave chipped stone collection.

BLANK TYPE	PORTION	MODIFICATION	PATINATION	ABRASION	DORSAL CORTEX
Blade	Complete	None	None	None	0
Flake	Proximal	Edge-damage	Light	Light	<50%
Core	Medial	Retouch	Moderate	Moderate	>50%
Angular Debris	Distal	Indeterminable	Heavy	Heavy	100%

Each artifact was examined macroscopically for modification to its edges. If modifications were observed it was recorded as either retouch, edge damage, or indeterminable. Artifacts categorized as having retouch exhibit patterned removal of flakes from one or more edges. The category "edge damage" includes artifacts with unpatterned flake removals or nibbling. For the purposes of this study such modifications are considered to be damage sustained post-depositionally and not the result of intentional use of the artifact. Microscopic use-wear analysis may alter the categorization of some artifacts but is beyond the scope of this thesis. Artifacts were categorized as "indeterminable" if the edges were obscured by chemical or mechanical weathering, regardless of the overall morphology of the artifact (Figure 4.4). In addition, relative degrees of patination and abrasion were recorded on a scale from 0 (none) to 3 (heavy).

All data was entered into Microsoft Exel spreadsheet. Descriptive statistics and graphs were generated using Microsoft Exel or Statistical Package for the Social Sciences (SPSS).

Figure 4.1 Type 1 refit: a core and articulated blade (Refit Set 6).

Figure 4.2 Type 3 refit: Conjoining fragments of a bilaterally retouched blade (Refit Set 26).

Figure 4.3 Example of Type 1 and Type 3 refits in the same refit set. Two conjoining flake fragments form a complete flake that refits in a ventral-dorsal articulation to a complete flake (Refit Set 18).

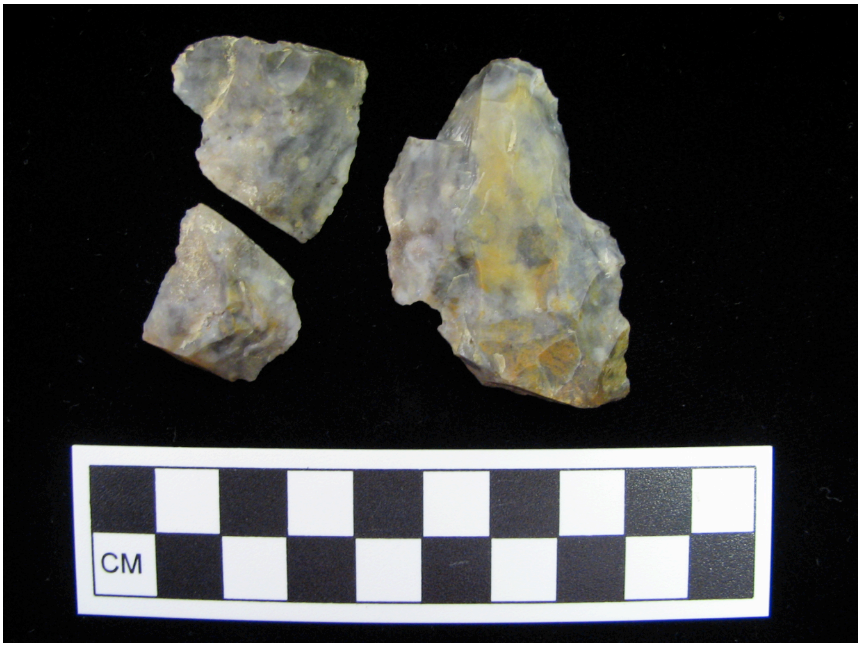


Figure 4.4 Example of artifacts where modification is obscured by chemical or mechanical weathering and classified as indeterminable.

Chapter 5: Results and Discussion

These results are based on systematic refitting of the chipped stone assemblages from levels D-L of Vindija Cave. The goal of this study is to determine how much, if any, vertical migration of artifacts has occurred since the time of their original discard and in so doing to address the contextual and stratigraphic integrity of the assemblages in question. All non-quartz chipped stone artifacts with known vertical provenience (n=1276) were included in the refitting study. Quartz artifacts were not considered because their homogenous appearance does not lend itself to refitting, especially given the time constraints. Among the chipped stone utilized in this study a total of 64 artifacts, or 5% of the collection utilized, were successfully refit. These refitted artifacts form 29 Refit Sets with each set being composed of 2-4 artifacts (Table 5.1).

The proportion of an assemblage able to be refit is dependant on multiple factors including (1) the conditions of preservation and site formation processes, (2) the proportion of the site that was excavated, (3) site organization and function, including reduction and discard behavior, and (4) methods of excavation and curation practices. The degree to which these factors may affect the artifact assemblages will vary from site to site and there is no expectation for the rate of success when refitting a collection. Variability in refitting rates between sites is illustrated in a survey of 28 sites in which the method was employed and where the proportion of a collection refitted ranged from 0.4% to 66% (Cziesla 1990:24-25).

The frequency of refitting artifacts in a collection is not an end in itself. Rather, the utility of refitting as an analytical method is in the contribution that the refit data can bring to site interpretation, with regard to site formation, taphonomy, and human behavior through the occurrence of refitting artifacts. Taken in this context, the refitting rate of 5% for the Vindija chipped stone collection is sufficient to address questions of stratigraphic integrity and site formation processes as was very successfully done by Villa (1982, 1983) at Terra Amata with a refitting rate of 4.8%.

The frequency distribution of artifacts involved in refit sets by strata is shown in Figure 5.1. This pattern agrees with the frequency distribution of the total chipped stone assemblage (Figure 5.2) and the stratigraphic position within the cave deposits is not a factor in determining the likelihood of an artifact to be successfully refitted.

Those artifacts that were successfully refitted do not differ drastically in size from the chipped stone assemblage as a whole. Table 5.2 compares the mean, median, standard deviation, and range of weights in grams for the refitted artifacts to the same measurements for the total chipped stone assemblage (a single outlying artifact weighing over 1000 grams was removed from the chipped stone assemblage for this statistic). The measures of central tendency show that the refitted artifacts are slightly lighter than the chipped stone assemblage and, accordingly, have a mean that is slightly lighter than that of the total chipped stone assemblage. There is some indication that smaller items are more readily displaced than larger items when exposed to certain post-depositional processes such as trampling (Stockton 1973, Villa and Courtin 1983), bioturbation (Erlandson 1984), argilliturbation (Hofman 1986, 1992), or alternate wetting and drying of sediments (Moeyersons 1978). Any of these processes may have occurred at Vindija though the refitted artifacts are on average only 2.2 grams lighter than the remainder of the chipped stone assemblage and this small difference in size does not explain the separation of the refitted artifacts. The purpose here is to establish that in terms both of size and vertical distribution, the artifacts that were successfully refitted do not differ significantly from the chipped stone assemblage as a whole.

Table 5.1 Summary of 29 Refit Sets from the chipped-stone assemblages from Levels D-L of Vindija Cave.

REFIT SET	NUMBER OF ARTIFACTS	STRATA INVOLVED	GROUP	TYPE	COMMENTS
1	3	E/F Fd/s G3-4	D	1	Sequential removal of three secondary decortication blades
2	2	Fd/d	A	1	Blade refit to a core
3	2	E/F G3	D	1	Flake fragment refit to flake
4	2	D G/F	D	1	Blade fragment refit to core fragment/tool
5	2	D G1/G3	D	1	Blade fragment refit to core fragment
6	2	D E/F	D	1	Microblade refit to exhausted microblade core
7	3	Fd/d G/F G2	D	1	Secondary decortication flake refit to two conjoined flake fragments that form a complete secondary decortication flake
8	2	D Fd/s	D	1	Flake refit to exhausted core
9	2	G3	A	1	Flake fragment refit to flake/core
10	2	G G4-H	C	1	Two fragments of a cobble core
11	2	K K/L	B	1	Primary decortication flake refit to tested cobble core
12	2	G G3-4	C	1	Primary decortication flake refit to tested cobble core
13	3	G G3	C	1	Flake refit to a conjoined split flake
14	2	G G3-4	C	1	Split cobble
15	3	E/F G G3/G4	D	1	Two flakes removed sequentially from a flake/cobble core
16	2	E/F Fd/s	D	1	Two primary decortication flakes
17	2	G	C	1	Two primary decortication flakes
18	3	G5 I/J K	D	1	Two refitted flakes reduced by bipolar technique; one flake is composed of two conjoined fragments

REFIT SET	NUMBER OF ARTIFACTS	STRATA INVOLVED	GROUP	TYPE	COMMENTS
19	2	I+J	A	1	Unifacially worked blade and a thinning flake
20	2	G1 G1/G3	C	1	Two sequentially removed distal flake fragments
21	2	D/E Fd/d	D	1	Two flakes removed from opposing striking platforms
22	3	Fs Fd/s Fd	D	3	Three conjoined pieces of angular debris
23	2	Fs G3-4	D	3	Two fragments conjoin to form a complete blade
24	2	F G1	B	3	Two fragments conjoin to form a complete unilaterally retouched endscraper
25	2	E F	B	3	Two fragments conjoin to form a thin, bilaterally retouched blade
26	2	G/F G1	B	3	Two fragments conjoin to form a complete, bilaterally retouched Aurignacian blade
27	2	G1-5 G3-5	C	3	Two fragments conjoin to form a complete flake tool; broken during excavation
28	2	G3-4	C	3	Two conjoined flake fragments
29	2	G G1	C	3	Two fragments conjoin to form a complete, bilaterally retouched Aurignacian blade

Figure 5.1 Frequency distribution of refitted artifacts from Refit Sets 1-29 by strata.

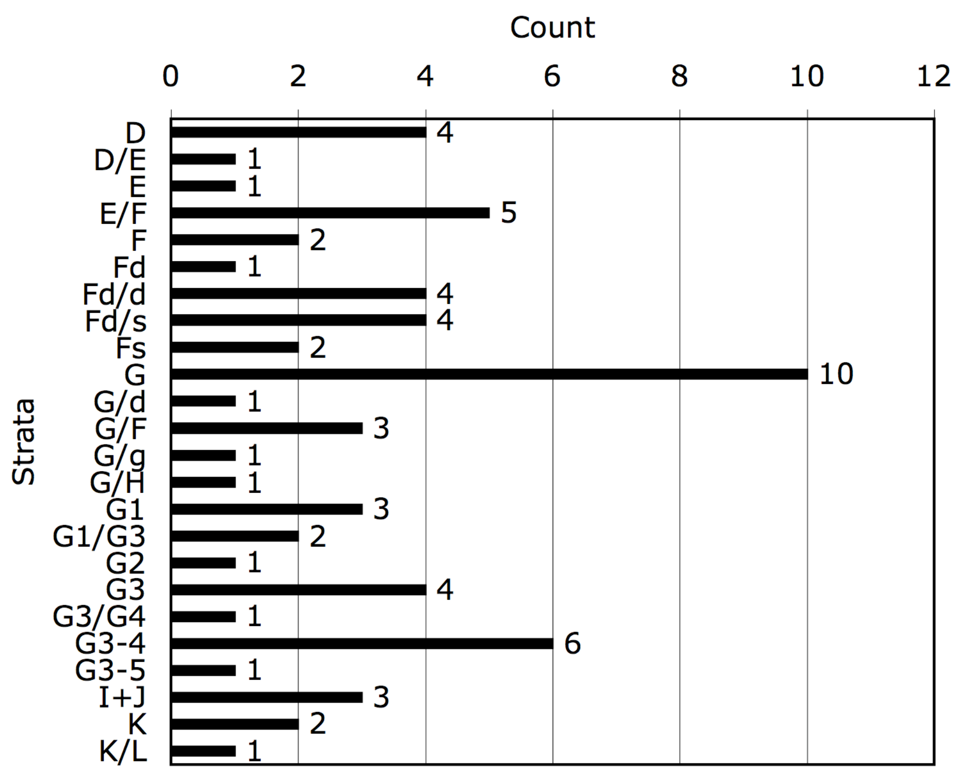


Figure 5.2 Frequency distribution of the chipped stone assemblage utilized in the refitting study by strata.

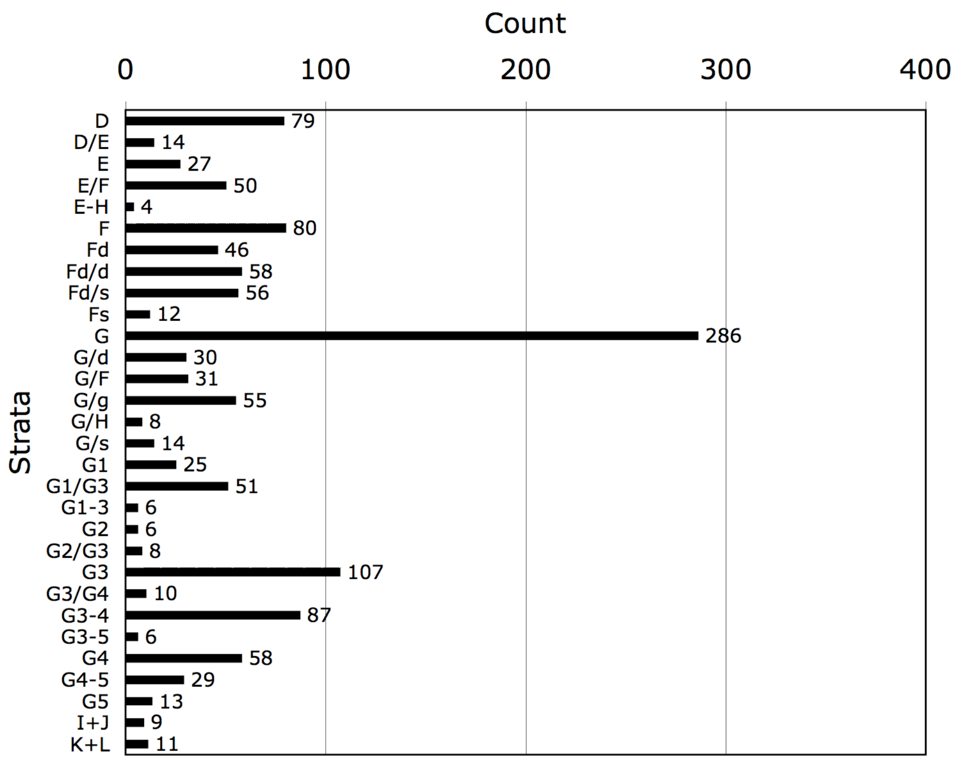


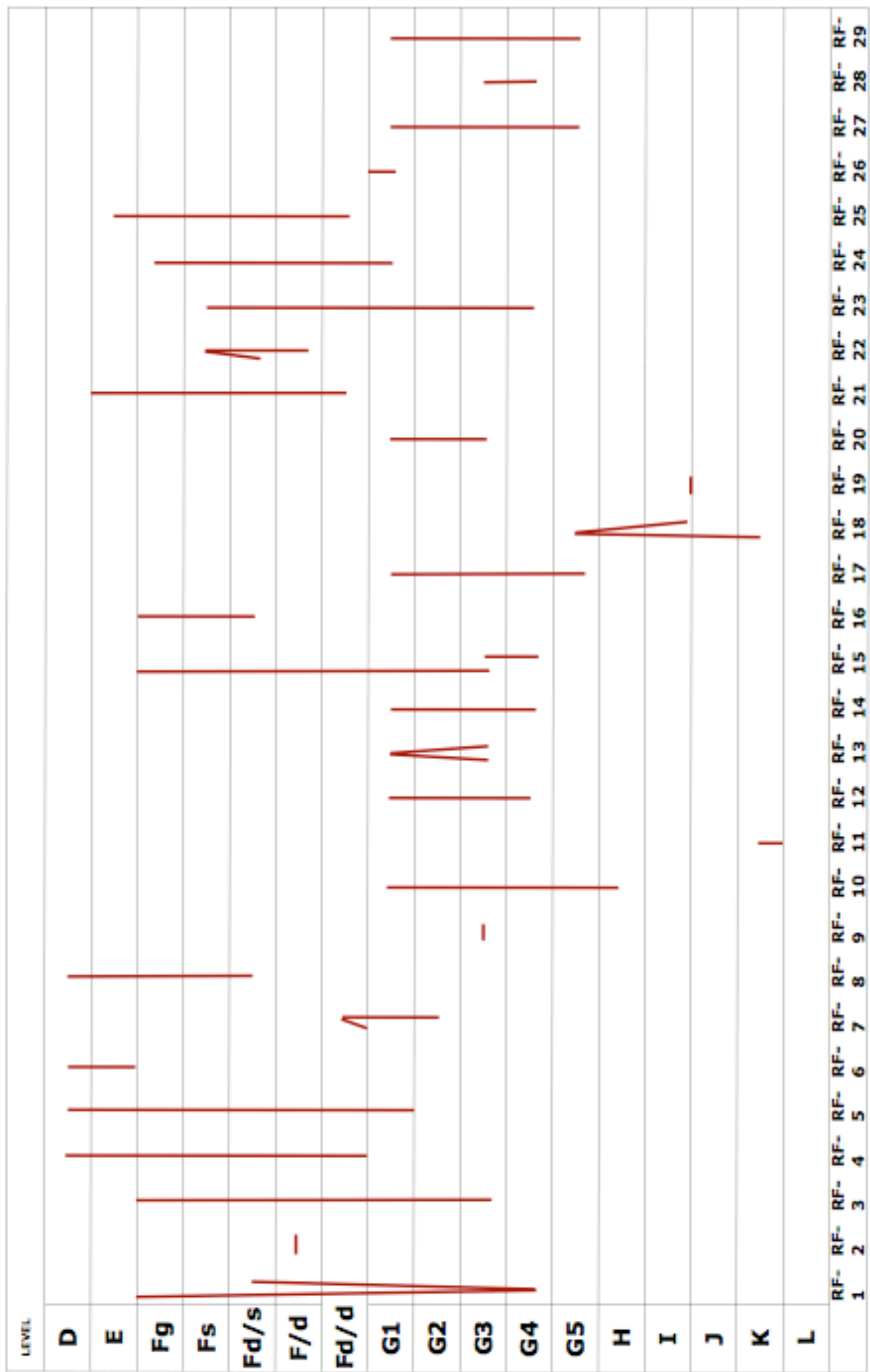
Table 5.2 Comparison of weight in grams of the refitted artifacts (n=64) to the total chipped stone assemblage minus a single outlier (n=1275).

	MEAN	**MEDIAN**	**STANDARD DEVIATION**	**RANGE (min-max)**
Total Assemblage	16.6	7.3	45.0	0.1 – 709.4
Refitted Artifacts	14.8	5.0	34.8	0.4 – 270.2

5.1 The Stratigraphic Relationship of Refitting Artifacts

The stratigraphic relationship of the refitting artifacts in each refit set is integral to understanding the vertical displacement of archaeological materials. Figure 5.3 graphically depicts the vertical distribution of artifacts within each refit set from the Pleistocene strata of Vindija. For reasons discussed below, it is not possible to accurately measure the vertical distance separating refitting artifacts. A more useful measure of the vertical displacement of materials is the comparison of stratigraphic units from which the artifacts were recovered. Refit sets are grouped into four categories according to the stratigraphic relationships of the individual artifacts within each refit set. These groups are comprised of refit sets where all artifacts originate from the same level (Group A), from adjacent levels (Group B), from overlapping levels (Group C), and refit sets where artifacts originate from levels separated by one or more stratigraphic units (Group D). The frequencies of each of these categories are shown in Table 5.3.

Figure 5.3 The stratigraphic relationship of refitted artifacts within 29 Refit Sets identified among the chipped stone assemblage of Vindija Cave. Graph is not to scale.



Vertical Distance between Refitting Artifacts

Any measure of vertical distance between artifacts recovered from Vindija must be viewed as a very rough estimate. Depths below surface of each stratigraphic unit were recorded in three witness profiles, Pyramids I, II, and III (Malez and Rukavina 1975; Malez et al 1984). These measures were not recorded at regular intervals during excavation and it is therefore impossible to know the precise depth of the strata at any location in the cave apart from the two remaining witness profiles (Figures 3.1 and 3.2). Depths of some stratigraphic units are given as ranges (e.g. Level G1: 8-20cm) and these values likely represent the observed fluctuation of these strata in the excavated portions of the cave, however, the lack of spatial data for these depths renders them useless with regard to reconstruction of the actual spatial or vertical distribution of the archaeological materials. Even if one takes the published depths from the witness profiles as representative of the cave deposits on the whole, which is problematic for many reasons, and, particularly so considering the occurrence of cryoturbated sediments in portions of the cave (Figure 3.4 and see Malez and Rukavina 1975 for additional documentation), the estimation of vertical distance between refitting artifacts remains hampered by the lack of spatial data and the fact that precise depths at which artifacts were recovered was not recorded.

As it is not possible to know the depth within the stratigraphic unit that the artifacts were recovered, refit sets belonging to Group D, those separated by at least one level, provide the most accurate estimation of vertical distance between refitting artifacts. Group D comprises 48.4% (n=31) of the total 64 refitted artifacts from the assemblage utilized in this study and is the single largest category of refit sets at 44.8% (n=13) of those identified in this study. No values were calculated for refit sets in Group A, B, or C. These refitting artifacts potentially could have been recovered in close stratigraphic association. Unfortunately, the manner in which they were collected and documented precludes a confident determination of the distance by which they were separated.

For the purpose of these estimations of vertical distance it is assumed that artifacts were recovered from the base of the uppermost level and from the top of lowermost level, and accordingly, the levels in which the artifacts were recovered are not included in the calculation. In the interest of maintaining the most conservative measure of vertical distance the published *minimum* depths (according to either Malez and Rukavina 1979 or Malez and Ullrich 1982) of all levels in between the refitting artifacts are added together for a *minimum* value of vertical distance by which they were separated when they were recovered during excavation (Table 5.4). Estimated vertical distance of artifact in Group D ranges from 8 cm to 230 cm with an average distance of 56.3 cm. There is minimal utility in comparing the estimated minimum distance of vertical separation at Vindija to sites where more precise measurements are possible. It is worth noting that the estimated average vertical separation of refitting artifacts at Vindija is slightly greater than the vertical spread of refitting artifacts at sites such as Meer II (Van Noten et al 1980:51) and Terra Amata (Villa 1982:284) where vertical spreads of up to 45 cm and 40 cm were reported, respectively, and, is less than the reported vertical spread of more than one meter at

Gombe (Cahen and Moeryersons 1977:813). The estimated range of vertical displacement at Vindija (8-230 cm) is remarkably larger than documented examples of artifact migration generated experimentally (Gifford-Gonzalez et al 1985, Stockton 1973, Villa and Courtin 1983). Observed examples of vertical separation of contemporaneous artifacts in stratified cave deposits include the Abri Dufaure (Straus et al 1988) where the majority of refitting artifacts were vertically distributed within a range of 4-43 cm and with a maximum vertical spread of 76 cm (Petraglia 1992:164).

It warrants reiterating that despite the significant distance separating the refitting artifacts at Vindija, these values are a very rough estimate and are generated using the most conservative measure. The *actual* vertical distance separating refitting artifacts was likely greater and in some cases may have been considerably greater. While data from refitting analysis indicates that considerable displacement has occurred among the cultural materials at Vindija, the lack of precise spatial information as discussed above precludes a more accurate determination of the degree of vertical displacement. A more useful measure of the degree to which archaeological materials from Vindija have been subjected to vertical displacement is the proportion of refitted artifacts found within the same, adjacent, or non-adjacent strata.

Table 5.3 Frequency of Refit Sets by Group indicating their stratigraphic relationship.

GROUP	STRATIGRAPHIC RELATIONSHIP	NUMBER OF REFIT SETS	PROPORTION OF 29 REFIT SETS
A	Same Strata	3	10.3%
B	Adjacent Strata	4	13.8%
C	Overlapping Strata	9	31.1%
D	Separated by 1+ Strata	13	44.8%

Table 5.4 Estimated minimum vertical distance separating refitting artifacts separated by one or more stratigraphic unit (Group D).

REFIT SET	NUMBER OF ARTIFACTS	NUMBER OF STRATA	ESTIMATED VERTICAL DISTANCE
1	3	7	20-41 cm
3	2	7	39 cm
4	2	6	90 cm
5	2	7	98 cm
6	2	1	<60 cm
7	3	1	8 cm
8	2	3	71 cm
15	3	7	30-49 cm
16	2	2	11 cm
18	3	5	100-230 cm
21	2	4	84.5 cm
22	3	1	8 cm
23	2	5	28 cm

Movement of Artifacts through Stratigraphic Units

Only 10.3% (n=3) of the refit sets identified in this study originated from the same stratigraphic unit (Group A) and those occur in Levels F/d, Level G3, Level I/J, and Level K. Refitting artifacts recovered from adjacent stratigraphic units (Group B) account for 13.7% (n=4) of the total refits. Vertical provenience of several artifacts consists only of a stratigraphic range from which they were collected. These include artifacts labeled only with the complex from which they were recovered (e.g.

Complexes F and G) and artifacts whose exact location within a range of levels was uncertain during excavation (e.g. G3-5). Refit Sets for which the ranges of possible vertical proveniences overlap (Group C) comprise 31.1% (n=9) of the refitted materials. Artifacts labeled in this way are dubious for determining stratigraphic relationships of refitting artifacts as there is no way to ascertain whether or not these artifacts were, or were not, in stratigraphic association at the time of excavation.

The majority of refit sets are composed of artifacts that appear to have migrated through one or more discreet stratigraphic units (Group D). Nearly half of the 29 Refit Sets identified in this study (n=13, or 44.8%) demonstrate the vertical movement of artifacts through stratigraphic units, that is, the levels from which the refitting artifacts originated are non-adjacent and are separated by one or more additional level. Of these, 69% (n=9) cross through *three or more* reportedly undisturbed stratigraphic units. One set of refitting artifacts passes through two stratigraphic units, and three sets of refitting artifacts pass through one stratigraphic unit. Artifacts involved in trans-stratigraphic refits account for 48.4% (n=31) of all refitted artifacts and 2.4% of the total chipped stone assemblage from Vindija.

5.2 Frequency of Refit Types

The majority of the Refit Sets identified among the chipped-stone assemblage (n=21, or 72%) are Type 1 refits representing stages in the lithic reduction process. The presence of these refits demonstrates that the reduction of both flake and blade cores took place within the cave. No examples of the reshaping or resharpening of an objective piece (Cziesla's Type 2) were observed among the refit sets and it is not known if this is a consequence of employment of methods of recovery that favored the collection of larger, more readily visible artifacts, or an indication that tool maintenance did not occur on site. The remainder of the refit sets are Type 3 (n=8 or 28%), representing chipped stone artifacts broken by cultural processes other than the intentional working of stone (e.g. trampling subsequent to discard), or by natural processes (e.g. roof fall, freeze-thaw, etc.). The presence or absence of sediment, patina, edge damage, and retouch on the articulating surfaces of artifacts in this category indicate that in all but one case they were broken at an unknown time prior to excavation, though the specific mechanism of their separation is unknown.

An example of breakage as a result of excavation activities is evidenced in Refit Set 27 (Figure 5.4) where two flake fragments articulate to form a flake tool. The break is fresh and no sediment or modifications are present on the articulating surfaces. Fresh flake scars are present on the dorsal faces of both fragments and appear to be the result of impact with a hard object, likely a pick-ax or shovel.

Two examples of refit sets involving more than two articulating artifacts within the same reduction sequence were identified during this study and each of these involved only three artifacts (Refit Set 1 and Refit Set 15). The inability to reconstruct any extensive series of reduction, as was accomplished at Meer II (Cahen et al 1979, Van Noten et al 1980, Cahen and Keeley 1980) and other Paleolithic sites, underscores the importance of depositional context and site formation processes to the integrity of artifact assemblages. Meer II is a single component, open-air site that was covered by alluvium soon after its abandonment, preserving the remains of discreet activities with a relatively small degree of post-depositional alterations. Cave settings typically are more complex and dynamic, with much greater opportunity for artifacts to become displaced by natural processes (Farrand 2001b). Cultural processes such as recycling, trampling, or earthmoving may also contribute to the displacement of artifacts, particularly when no sterile levels separate cultural materials from different occupation episodes, as is the case at Vindija.

The occurrence of an assemblage in stratified cave or rockshelter context alone does not preclude the possibility of reconstructing an extensive series of lithic reduction. The Abri Dufaure is a stratified rockshelter where refitting analysis assisted in identifying 5 discreet activity areas within the Paleolithic strata (Petraglia 1992, Straus et al 1988). Four lithic reduction sequences were reconstructed and the number of artifacts involved ranged from 6 to 110. It is therefore necessary to find other explanations for the lack of extended series of lithic reduction among the Vindija collection.

While biases of preservation and recovery certainly impose limits on the probability of reconstructing extensive episodes of lithic reduction at Vindija, the possibility also remains that extensive lithic reduction did not take place within the cave. This possibility is refuted by the presence of Type 1 refits which provide unequivocal evidence of *in situ* lithic reduction. Further, in several cases (Refit Sets 1, 2, 4, 5, 6, 8, 9, 18, 19, and 20) flake scars on one or both refitting artifacts in a Refit

Set indicate that additional flakes or blades were removed from the same core at or near the time as those that were successfully refit, although these intermediate removals were not identified among the chipped stone assemblage. It is entirely possible that more refitting of the Vindija collection will discover additional refitting artifacts, perhaps filling in some of these missing pieces. Even in the absence of the objective pieces themselves sufficient evidence of their production is demonstrated by refitting analysis. The high number of Type 1 refits indicates the *in situ* reduction of lithic material. Along with the proportionately high number of exhausted cores (n=46, or 53.4% of all cores) recovered from the strata of Vindija and the additional evidence of primary, secondary, and tertiary stages of lithic reduction, it is evident that the production of blanks was a key activity at this location. Flake and blade blanks were produced from lithic materials procured from nearby secondary sources and were probably intended for use at locations other than the cave itself.

Figure 5.4 Refit Set 27: a flake tool broken during excavation.

5.3 Refit Sets and Site Formation

Given the considerable vertical distance between refitting artifacts and evidence of the movement of artifacts through stratigraphic units, it is evident that the Pleistocene deposits of Vindija and the artifacts contained within them have undergone considerable post-depositional alterations since they first entered the archaeological context. At this stage the specific causes of the vertical movement of artifacts is unknown. Nor is it known if only one artifact within each Refit Set, or all of the artifacts within the refit set, have been subject to vertical displacement. Their stratigraphic relationship and comparisons of their taphonomy provide some clues as to the post-depositional processes that may have contributed to their separation in particular, and site formation in general.

Size Sorting and the Directionality of Displacement

There is a slight tendency among the refit sets for the smaller of the artifacts to be stratigraphically located below others in its refit set. Using refit sets belonging to Groups B and D, that is, those artifacts from either adjacent or stratigraphically separated levels, a size ratio value was calculated for each artifact in the refit set by dividing the weight by the maximum dimension of the artifact. In four cases (Refit Sets 7, 15, 18, and 22) the smallest of the artifacts was located stratigraphically in between the two larger artifacts rendering these ambiguous for investigating size sorting. Of the remaining 13 refit sets the smaller of the two artifacts was located stratigraphically below the larger in 8 cases or 61.5% of the cases. Interestingly, the percentages of cases where the smaller artifact is positioned under the larger artifact differs from Group B to Group D. The smaller of the artifacts is positioned stratigraphically below the larger artifact in just over half (55.5%) of those refit sets where artifacts are separated by one or more stratigraphic unit (Group D) whereas three-fourths (75%) of those refit sets composed of artifacts from adjacent levels exhibit this same pattern.

Experimental studies have shown that trampling may result in the downward displacement of smaller artifacts while larger artifacts remain closer to the surface (Stockton 1973, Gifford-Gonzales et al 1985). This may explain the pattern of smaller artifacts located stratigraphically below larger objects, particularly in the case of those artifacts recovered from adjacent strata where activity on the surface may have pushed objects into underlying sediments. Similarly, the "size effect" as documented by Baker (1978) may result in larger, less easily displaced artifacts remaining on an exposed surface, even as that surface aggrades over time. However, given the small sample size and the unknown significance of the size difference in the artifacts in question, this remains only a working hypothesis. Further investigation will hopefully reveal a more meaningful pattern in the size distribution of refitting artifacts.

Taphonomy

The presence or absence of edge-damage and relative degrees of abrasion and patination were recorded for the entire chipped stone assemblage. Edge-damage was observed on 12.1% of the collection and appears to occur evenly throughout the strata. Edge-damage was present to a lesser degree on those artifacts that were successfully refitted accounting for 4.7% of all refitted artifacts. Those artifacts exhibiting edge-damage belong to Refit Sets 9, 20, and 23 and are from Levels G1, G3, and G3-G4. Experimental studies have shown that trampling may cause edge-damage to lithic materials depending on the penetrability and texture of the matrix (McBrearty et al 1998, Gifford-Gonzales et al 1985). Level G1 is composed of clay while Levels G3 and G4 are loess-like and sandy (Table 3.1). Cryoturbation is also reported to leave distinct edge-damage on archaeological materials (Laville et al 1980). The relatively small amount of edge-damage to the chipped-stone collection at Vindija and, specifically, to those artifacts strongly suspected of being vertically displaced is unexpected. The majority of the strata in the cave are composed of silt and sand, with varying amount of larger stones and these soft substrates, in combination with a relatively light amount of trampling and/or infrequent site use are all possible explanations for the lack of significant edge-damage.

Seven of the 29 Refit Sets (Refit Sets 3, 6, 11, 14, 15, 28, and 29, see Appendix A) are composed of artifacts with differing degrees of patination, suggesting that they were post-depositionally exposed to differential weathering conditions after their separation. Variability in weathering conditions in cave settings is common (Farrand 2001b) and differential weathering of articulating artifacts can occur due to lateral or vertical separation, or both. In six of these cases artifacts were recovered from different strata and this is a likely explanation of their condition. No further patterns in the distribution of edge-damage, abrasion or patination, were observed in this study. Further exploration may reveal meaningful patterns in the vertical or spatial distribution of these attributes and assist in reconstruction of site formation processes at Vindija Cave.

5.4 Refits and Assemblage Composition

There is substantial evidence from refitting analysis that the Paleolithic deposits at Vindija have been subject to post-depositional processes resulting in the vertical displacement of artifacts. The degree to which mixing between strata has occurred is of significant importance to the interpretation of archaeological materials found in stratigraphic association, particularly those levels with no clear cultural determination.

Mixing of materials from different strata

Morin and colleagues (2005) have recently used refitting of faunal remains to address the stratigraphic integrity and chronological resolution of occupation levels at Saint-Césaire in southwest France. A "mixing value" was calculated for levels involved in inter-level refits by dividing the number of times an inter-level refit occurs in that level by the total number of refits found within that level. Mixing values calculated in this manner for the Upper and Middle Paleolithic strata involving inter-level refits from Groups B and D are shown in Table 5.5. The sample of refitting artifacts at Vindija is much smaller than the sample at Saint-Césaire and the strength of this measure for the Vindija materials may be reduced as a consequence. It is applied here merely as a relative measure of mixing between strata and not as an absolute measure of the degree of mixing.

As stated above, the majority of refits identified in this study were inter-level refits and involved 38 artifacts accounting for 59.4% of the total number of refitted artifacts. An *initial* mixing value of 1.00 was found for nearly all of those strata involved in inter-level refits. This is not necessarily an accurate measure of mixing in these strata because in the majority of these cases the level is represented by only one refitted artifact. A more informative comparison is those strata involved in multiple inter-level refits. A *final* mixing value for these strata is calculated by multiplying the mixing value obtained previously by the total number of inter-level refitted artifacts (Table 5.5). The highest final mixing values are seen in Levels D, E/F, Fd/s, and G/F. Additional strata with a sample size greater than one that are involved *only* in inter-level refits include Complex F, Level Fs, and Complex K.

Low initial mixing values and moderate to low final mixing values were found for Levels Fd/d, G, G1, G3/G4, and I/J. This at first appears to indicate relatively less mixing, however, three of these strata, Levels Fd/d, G3, and I/J, are also represented by the three cases of intra-level refits. A degree of mixing of materials between strata is evident, then, even in those levels where the occurrence of refits within a single stratum may at first appear to suggest no mixing of materials.

Based on mixing values and the high frequency of inter-level refits it is evident that mixing of archaeological materials has occurred between strata at Vindija. Final mixing values indicate that Levels D, E/F, Fd/s, and G/F may represent some of the most disturbed strata,. Several of the strata are involved only in inter-level refits, and mixing of materials between strata can be seen even in those strata in which intra-level refits were found. These results indicate that there are no strata free of some degree of mixing. The extent to which the presence of refitting artifacts in each stratum is a function of the number of artifacts present in that stratum is addressed with an additional calculation. The number of artifacts in each level that are involved in inter-level refits is divided by the total number of artifacts in the assemblage for that level providing another relative degree of mixing. Results are shown in Table 5.6.

The frequency with which refitting artifacts occur in Levels Fs, G2, and I/J (16.7%), Level E/F (10%), Level G/F (9.7%), and Level G1 (8%) stand out indicating potentially disturbed strata. All refitting artifacts in Level E/F were involved in *non-adjacent* inter-level refits (Group D) and articulating artifacts were found ranging vertically from Level D to Level G3-4.

The frequency with which Level G/F and Level G1 are involved in inter-level refits and the relatively high mixing values for Level G/F and moderately high final mixing value for Level G1 is particularly interesting considering the “mixed” character of the stone tool assemblage (Karavanić 1995). Artifacts articulating to those in these levels are stratigraphically distributed from Epigravettian Level D to Mousterian Level G2. There are no examples of intra-level refits in either Level G/F or Level G1. It follows, then, that Level G/F and Level G1 represent the most disturbed strata at Vindija Cave. The extent to which this a consequence of the methods of collection and documentation is discussed below.

Table 5.5 Mixing Value for strata involved in inter-level refits.

LEVEL	NUMBER OF REFITTNG ARTIFACTS	NUMBER OF ARTIFACTS IN INTER-LEVEL REFITS	INITIAL MIXING VALUE	FINAL MIXING VALUE
D	4	4	1.00	4.0
D/E	1	1	1.00	1.0
E	1	1	1.00	1.0
E/F	5	5	1.00	5.0
F	2	2	1.00	2.0
Fs	2	2	1.00	2.0
Fd/s	4	4	1.00	4.0
Fd	1	1	1.00	1.0
Fd/d	4	2	.500	1.0
G/F	3	3	1.00	3.0
G	10	1	.100	.10
G1	3	2	.667	1.3
G1/G3	1	1	1.00	1.0
G2	1	1	1.00	1.0
G3	1	1	1.00	1.0
G3/G4	7	3	.429	1.3
G5	1	1	1.00	1.0
I/J	3	1	.334	.33
K	2	2	1.00	1.0

Table 5.6 Proportion of chipped stone assemblage involved in refits by level.

LEVEL	TOTAL ARTIFACTS	ARTIFACTS IN INTER-LEVEL REFITS	PROPORTION OF ASSEMBLAGE REFIT
D	79	4	.051
D/E	14	1	.071
E	27	1	.037
E/F	50	5	.100
F	79	2	.025
Fs	12	2	.167
Fd/s	56	4	.071
Fd	46	1	.022
Fd/d	58	2	.034
G/F	31	3	.097
G	286	1	.003
G1	25	2	.080
G1/G3	51	1	.020
G2	6	1	.167
G3	107	1	.010
G3/G4	97	3	.031
G5	15	1	.077
I/J	6	1	.167
K	9	2	.222

Cohesion of the Assemblages

The frequency and distribution of refitting artifacts demonstrates that some mixing of cultural materials has occurred between two or more geological strata. There is no way to determine with certainty which of the strata the refitting artifacts were initially deposited. It is plausible that post-depositional processes have vertically displaced all artifacts in a Refit Set and that none were recovered from the level in which they were initially discarded. In some cases it may be possible to determine to which strata the complete artifact most likely belongs. Refitting artifacts were found in the same strata for Level Fd/d (Refit Set 2), Level G3 (Refit Set 9), and Level I/J

(Refit Set 19). Unfortunately none of these artifacts are diagnostic though, as one may expect, blade technology is evidenced in Aurignacian Level Fd/d while flake based reduction of Refit Set 9 fits with the Mousterian attribution of Level G3. All else being equal, it appears that these artifacts are reasonably in place.

Blade technology is present in Refit Sets 1, 4, 5, 6, and 23. These Refit Sets involve at least one Upper Paleolithic level and one Mousterian or culturally undetermined level. Refit Set 1 consists of three sequentially removed blades. Two were found in Epigravettian Levels E/F and Fd/s and the third was recovered from Mousterian Levels G3-4. Though the cause of their distribution is unknown, these three artifacts most likely belong to one of the Epigravettian levels. The same is true of Refit Set 23 that involves Epigravettian level Fs and Mousterian Level G3-4 and Refit Set 5 that involves Epigravettian level D and Mousterian Level G1/G3. Refit Set 4 ranges from Epigravettian Level D to Level G/F. Although the lower level is also Upper Paleolithic these artifacts are more probably associated with the Epigravettian. The lithic material of these refits is a very distinctive caramel chert that is common in the upper strata at Vindija. The same material is seen in refit set 6, which is composed of a microblade and exhausted microblade core recovered from the interface of Levels E and F (Level E/F) and Level D respectfully, and both of these levels have been attributed to the Epigravettian (Karavanić 1995). The grouping of these artifacts of this material with Epigravettian levels is further supported by Refit Set 4 where a core fragment recovered from Level G/F (Figure 5.5) was reworked into a very small endscraper that would be very out of place in an Aurignacian or Early Upper Paleolithic assemblage.

If the above scenario is correct, it would lead to the removal of an endscraper (#1559) from the Level G/F assemblage and decrease the Upper Paleolithic elements in Levels G1/G3 and G3-4 encompassing the terminal Mousterian. The conjoining of two broken Aurignacian blades (Refit sets 26 and 29) also decreases the formal tool count for Complex G by one, assuming the complete tool belongs to Level G1, and also decreases by one, either Level G/F or Level G1, depending on which level one chooses to place the complete tool. The cohesion of these levels is particularly important considering the significance they may have for understanding the Middle to Upper Paleolithic transition and the character of Early Upper Paleolithic assemblages.

Level G1 is stratigraphically situated between the Terminal Mousterian of Levels G2 and G3 and the Aurignacian of Levels G/F and Fd/d. The stone tool assemblage of Levels G/F and Fd/d are attributed to the Aurignacian though Fd/d contains some tools more likely originating from the upper strata (Karavanić 1995). The stone tool assemblage of Level G1 is composed of both Upper and Middle Paleolithic types and is attributed to the Aurignacian only on the presence of bone points (Karavanić 1995, Karavanić and Smith 1998). Given the relatively high mixing value for Levels G/F and G1, the frequency with which they are involved in inter-level refits, and the lack of refits within either level it seems probable that the materials in these strata have been subjected to some degree of mixing and that their cohesion as an assemblage is compromised. Another explanation may be found in the manner in which these artifacts were collected and documented.

The label “G/F” occurs on three artifacts involved in Refit Sets. Refit Set 4 has been discussed above and it was determined that this artifact (#1559) was not in primary context in Level G/F but, rather, was vertically displaced from the upper strata. In the other two Refit Sets (Refit Set 7 and 26) artifacts labeled G/F articulate to artifacts from Levels Fd/d, G1, and G2. Artifacts labeled “G/F” (excavation years 1975-1977) were recovered from the interface of Complex F and Complex G before the sub-division of these complexes had occurred and before Levels Fd/d and G1 were well defined and consistently recognizable during excavation. It is reasonable to assume that some of the artifacts bearing the “G/F” label originated in Aurignacian Level Fd/d and others originated in Level G1, while for some, the stratigraphic context may have been uncertain. In either case the cohesion of these three assemblages as meaningful units of analysis is questionable.

Figure 5.5 Refit Set 4: core fragment and articulating blade fragment. The core fragment has been worked into a small endscraper.

Recycling

Two Refit Sets demonstrate the recycling of materials from older deposits. The stratigraphic relationship of the refitted artifacts in combination with material evidence of the order of events provides special insight into the movement of materials within, and, between stratigraphic units. For the purpose of this analysis it is assumed that the cave floor was composed of a single sedimentary unit at the time artifacts were deposited. Given the complexity of deposition within caves (Farrand

1998, 2001b), this is not necessarily realistic and it is unfortunately not possible at present to determine the *actual* conditions at the time of occupation. Data from refitted artifacts will be of considerable aid should future research attempt to reconstruct the spatial distribution of the archaeological materials.

Refit Set #15

This Refit Set consists of a cobble core from which two successive flakes were removed (Figure 5.6). The core itself is a large cortical flake removed from a river cobble. Weathering on the ventral surface of this flake suggest that it was discarded and unused for some time prior to the point at which the two flakes were removed. The weathered surface is present on the dorsal face of the first flake to be removed from this core. The dorsal scar left on the core at the removal of the last flake is fresh in comparison to the overall weathering on the remainder of the face. These artifacts belong to Group D. The first flake removed from the core was recovered from Level G3-4, the second flake removed was recovered from within Complex G, and the core, the older of the three artifacts, was recovered from a younger stratum, Level E/F. These three artifacts unfortunately are not diagnostic and could belong to any of the Paleolithic levels.

One explanation for the stratigraphic distribution of these artifacts is that the core/flake was acquired from the surface of the cave after its original discard, two flakes were removed and the core was discarded once again on the cave surface, presumably Level E/F where it was collected during the 1978 field season. The two flakes theoretically were deposited on the very same surface close in time to the discard of the core. These artifacts were both recovered in Complex G suggesting that they migrated downward at some time after their original deposit due to the actions of either biogenic or physiogenic processes.

Figure 5.6 A cobble core and two sequentially removed flakes. Differential weathering is evidence of recycling (Refit Set 15).

Refit Set #24

This refit set is composed of two conjoined blade fragments that form a unilaterally retouched endscraper (Figure 5.7). The proximal portion of the tool exhibits regular and continuous retouch for the entire length of one margin. The distal portion has been modified on the same margin though the retouch is less regular, more steep, and continues very slightly onto the surface that articulates to the proximal portion. This episode of retouch occurred after the original blade tool was broken. It is not known if the distal portion was made into an endscraper prior to, or subsequent to, the break. The distal portion of the artifact with evidence of modification after the break was recovered from Complex F, though its precise location within the 30-150cm thick Complex is unknown, the proximal blade fragment was recovered from Level G1, situated immediately below the base of Complex F. As a complete tool, whether an endscraper or unilaterally retouched blade, this artifact is of general Upper Paleolithic character and both typologically and technologically could be included in either the Epigravettian or Aurignacian assemblages within Complex F. The steep retouch of the distal portion subsequent to breakage is more typical of the Aurignacian than the Epigravettian and it is most probable, but by no means certain, that both the complete tool and the endscraper originated from Aurignacian contexts.

Figure 5.7 Conjoined bilaterally retouched endscraper. Post-break retouch is evidence of recycling (Refit Set 24).

5.5 Discussion

The refitted artifacts identified in this study, and particularly the two observed cases of recycling, demonstrate the complexity of the stratigraphic situation at Vindija. Villa (1982: 276) has noted an historical tendency of Paleolithic archaeologists to equate geological strata with cultural entities in the interest of establishing a cultural-historical sequence and this was certainly the case at Vindija. Each "cultural" assemblage represents an aggregate of artifacts, a palimpsest resulting from multiple occupations occurring during a geologically defined period of time. The investigation of behavioral and cultural implications of individual occupation episodes requires a higher degree of chronological resolution where the contemporaneity of objects may be demonstrated by refitting, taphonomy, or other means.

The majority of refit sets identified in this study represent artifacts that have moved through one or more stratigraphic unit. This indicates substantial vertical displacement of artifacts. Some strata were difficult to define during excavation, particularly within Complexes F and G. Unclear boundaries between stratigraphic units, for example between Levels Fd/d and G1and Levels E and F (Malez et al 1984) may have led to some difficulty in determining the context of some of the archaeological materials and refits between these levels, particularly those involving Level G/F, may be the result of uncertain context rather than actual movement of artifacts. Edge-damage was observed on only a small number of the refitted artifacts, and no meaningful pattern was observed in the abrasion or patination of refitting artifacts. Nevertheless, cryoturbation effected several of the Paleolithic levels at Vindija (Malez and Rukavina 1975), particularly Levels D, E, and G1 (Malez 1978a).

At Vindija, nearly half of all refit sets are separated by *at least* one stratigraphic unit. High mixing values at Saint-Césaire correspond to relatively thin sedimentary layers (Morin et al 2005) although this is not necessarily the case at Vindija. The highest final mixing values at Vindija occurred in Levels D, E/F, Fd/s, and G/F. Level D is one of the thickest, with no internal stratification and Level Fd/s is relatively thin in comparison (Table 3.1). Levels E/F and G/F are not immediately useful in this measure because they occur at the interface of two strata and are not represented by any depth measurements. This measure is quite informative as it indicates that these strata may not have been clearly identifiable during excavation and demonstrates how the manner by which artifacts were collected and documented may limit their utility for subsequent investigations. In addition, refits are found to occur at Vindija in a variety of sedimentary contexts ranging from sandy loess in Level D to clay in Levels Fd/s and Level G1 (Table 3.1).

The observation of a relatively small number of displaced artifacts does not necessarily suggest that the entire assemblage from any given strata is without cohesion. The technological and typological cohesion of Paleolithic assemblages at both Verberie (Audouze and Enloe 1997) and Meer II (Cahen and Keeley 1980) was established despite the fact that portions of both sites has been altered by post-depositional processes, allowing for relatively high-resolution interpretations of the archaeological materials. Data generated by refitting artifacts at Vindija hints at a potentially very significant issue regarding the interpretation of these materials in behavioral terms given the typologically and technologically mixed character of some assemblages from Vindija, particularly Level G1. The inclusion (or removal) of individual artifacts from small assemblages could potentially alter the character of the assemblages involved. This is particularly true if the artifacts hold typological attributes associated with specific cultural entities or techno-complexes, for example the Aurignacian, Mousterian, or Szeletian.

Relatively high mixing values and the frequency of inter-level refits for Levels G/F and G1 suggest that these are some of the most disturbed and least cohesive at this site. Indeed, in the course of articulating Neandertal bones, Malez observed that mixing had occurred between strata and regarding the justification for attributing them to Level G3 wrote (Malez and Ullrich 1982:16):

> "This is supported by the determination that Vi 226 (Level g) can be matched to Vi 265 (Level G3), Vi 227 (Level l) to Vi 254 (G3), as well as Vi 302 (boundary zone Fd and Fd/d) to Vi 204 (h=G3)." [Text translated from German by E.R. McGowan IV]

Clearly then, materials from Level G3 are moving both up and down, and in some cases arriving secondarily in an Aurignacian context. Levels Fd/d through Level G1 encompass the transition from the Middle to the Upper Paleolithic and cultural inventory of these levels is significant for understanding the biological and cultural dynamics that preceded the disappearance of Neandertals from the archaeological record. The mixing of typologically identifiable and diagnostic artifacts from multiple occupations in a single assemblage, as in Level G1, is all the more confounding in terms of cultural determination of these levels when the possibility that the mixing of materials left by different cultural entities is considered. While mixing values for Levels E/F, Fs, and I/J are also relatively high, the levels immediately above and below each of them contain typologically similar artifacts and the issue of mixing between these strata may have gone unnoticed as a result.

Refitting analysis has been used successfully at both the Abri Dufaure (Petraglia 1992) and Saint-Césaire (Morin et al 2005) to argue for the overall cohesion of archaeological levels. In both cases a low proportion of refits were found to cross through stratigraphic boundaries. Refitting data strongly suggests that archaeological materials at Vindija have been subject to vertical displacement as a result of post-depositional processes and 2.4% of the Paleolithic chipped stone assemblage was found to cross through stratigraphic boundaries. Refits were found involving all strata but *none* of the strata were limited to intra-level refits alone. It is concluded that post-depositional processes have lead to the mixing of materials between strata and to considerable vertical displacement of materials from their original location of deposit.

Refitting analysis has demonstrated that not all of the cultural materials from this site are in primary context. Though this study has focused on the chipped stone assemblage the potential for vertical displacement is extended to all classes of artifacts, including faunal remains and hominid bones. Until these contextual issues are addressed the question of the stratigraphic integrity of the Middle and Upper Paleolithic assemblages remains unresolved.

Chapter 6: Conclusion

The goal of this study was to determine if archaeological materials from the Pleistocene strata at Vindija Cave have been subjected to post-depositional vertical displacement. The stratigraphic integrity of the cultural materials was tested with the application of refitting analysis of chipped stone assemblages from the Upper and Middle Paleolithic strata. Five percent of the chipped stone assemblage was successfully refit and 2.4% of the collection demonstrates the vertical displacement of artifacts across stratigraphic boundaries. No appreciable differences in size or stratigraphic distribution separate the refitted materials from the remainder of the chipped stone assemblage, thus this sample is considered an unbiased and representative sample of the Vindija Cave materials.

For the moment the specific post-depositional processes responsible for the vertical separation of these materials are unknown and it is not currently possible to thoroughly reconstruct the site formation processes of Vindija Cave. The vertical displacement of archaic human skeletal remains due to cryoturbation was noted during excavation (Malez and Ullrich 1982:16) and cryoturbated sediments were observed in portions of the cave (Malez and Rukavina 1975). The occurrence of refitting artifacts and the infrequency of intra-level refits provide additional support the contention that post-depositional disturbances were a significant factor in the formation of the Vindija record, though the effects these may have had on the archaeological assemblages remains to be systematically evaluated.

Refitting data at Vindija Cave, while pointing to the vertical displacement of artifacts, has, in fact, raised more questions than it has answered. Saint-Césaire in southwest France is also a stratified cave site where late Neandertals occur with a transitional Early Upper Paleolithic industry (Hublin et al 1996). Unlike at Saint-Césaire, the depth of the stratum does not appear to have any relevance on the frequency of inter-level refits at Vindija Cave. Levels with the highest mixing values at Vindija Cave correlate neither to the depth of the geological deposit nor to its lithology. At present no meaningful patterns are evident with regard to size sorting or the direction of artifact displacement.

The large number of inter-level refits at Vindija Cave (44.8%) is highly suggestive of substantial vertical movement of materials *between* strata. The opposite pattern was observed at Saint-Césaire where only 1.2% of the refit sets were inter-level refits and the majority of refit sets were found from within the same level (Morin et al 2005). Three examples of intra-layer refits were identified in the course of this study, however, each of these strata was also involved in inter-level refits. It was determined at Saint-Césaire that very little mixing of occupation levels had occurred and that the assemblages provide a fine-grained chronological resolution. The same cannot be said for the assemblages at Vindija Cave. Refitting data demonstrates that, until other lines of evidence can show otherwise, the chronological resolution of the assemblages is relatively coarse-grained.

The cohesion of assemblages, even where the mixing of multiple occupations has occurred, may not be drastically affected provided one maintains large-scale perspective (Bailey 2007). Investigations of the behavioral implications from individual occupation episodes requires a high degree of chronological resolution, a situation rarely encountered in cave deposits where palimpsests of materials deriving from multiple occupations are often found within the same strata. No sterile levels separating the Paleolithic strata at Vindija Cave and the mixing of materials between strata that are typologically and technologically similar may have gone unnoticed without the application of refitting.

Refitting of artifacts also demonstrates that some of the most disturbed strata at Vindija Cave are among those that encompass the period of the Middle-Upper Paleolithic transition (Levels G/F and G1). Artifacts from these strata refit to others from Epigravettian, Aurignacian, and Mousterian levels. The typologically “mixed” character of Levels Fd and G/F are readily explained by the mixing of materials from different occupations that has brought into stratigraphic association materials of different ages and industries. Available radiocarbon dates for Level G1 range from 18,000 to 46,000 rcybp and supports the conclusions from refitting analysis that artifacts and materials of differing ages are mixed in Level G1.

The possibility that mixing has occurred with materials from discreet episodes of occupation is of considerable concern with regard to the Middle-Upper Paleolithic transition in Central and southeastern Europe. The existence of multiple techno-complexes in this region is commonly argued (Kozlowski 2004, Svoboda 2004, Svoboda and Bar-Yosef 2003). Many of these stone tool industries have yet to be firmly defined in terms of typology, chronology, or geography and a typological framework for the region is currently lacking. It is not surprising that the very levels that remain typologically ambiguous at Vindija Cave are those that span this culturally dynamic, but not yet well understood, period of time known as the Middle-Upper Paleolithic transition. Given the current record in Central Europe it would appear that rather than a simple act of replacement, the Middle-Upper Paleolithic transition was, in fact, a regionally variable process.

The possibility that the bone and stone tool assemblage from Levels G/F and G1 represents another transitional industry in the region is intriguing. Particularly the association of late-dated Neandertals with that industry in Level G1 and the co-occurrence of Neandertals with tools traditionally associated with anatomically modern humans. However another explanations for the unprecedented associations in Level G1 and other "mixed" assemblages is that they were generated by post-depositional processes and do not in fact represent a cohesive industry.

Refitting data strongly suggests that the materials in Levels Fd, G/F, and G1 have been brought into stratigraphic association by post-depositional movement of artifacts. While this does not refute the possibility that transitional industry or industries are present at this location, it does require that a fuller understanding of site formation history and evaluation of the contextual integrity of artifact assemblages become a priority in the ongoing investigation and discussion of the role of Vindija Cave in the Early Upper Paleolithic of Central Europe.

Binford (1977b, 1981) has shown that interpreting aggregates of artifacts at face value may lead to unjustified conclusions regarding human behavior. Contextual analyses are essential prerequisites to the interpretation of archaeological materials in behavioral terms. This study provides another example of how refitting can be instrumental in the investigation of the contextual and stratigraphic integrity of archaeological assemblages and should be employed wherever possible to enhance confidence in cultural sequences and behavioral inferences.

This refitting study has demonstrated that the stratigraphic integrity of the Paleolithic strata at Vindija Cave cannot be assumed. It is, however, only a starting point from which additional research may begin. The stratigraphic integrity of the Middle and Upper Paleolithic strata at Vindija Cave may be tested further with additional refitting of the lithic and faunal assemblages. Investigations of the taphonomy of the faunal and lithic materials will be beneficial to understanding the formational history of the site. Analysis of the cave deposits from a geoarchaeological perspective would greatly aid the interpretation of archaeological materials. The application of micromorphology to the remaining sediment profiles would provide a more complete picture of the depositional and post-depositional processes at Vindija Cave and undoubtedly shed new light on the sedimentary contexts in which archaeological materials were recovered. A series of radiometric dates from samples with known vertical provenience will be of great utility in teasing out the nuances of site formation and depositional histories at Vindija Cave, as well as establishing a tighter chronological framework for the site.

The archaeological record at Vindija Cave has great potential for understanding biological and cultural dynamics of the Early Upper Paleolithic. Direct radiocarbon dates on Neandertals place them toward the end of the Middle-Upper Paleolithic transition (Higham et al 2006) and earlier Neandertal specimens from Vindija are currently being used to build the Neandertal genome (Noonan et al 2006, Green et al 2006). Securing the archaeological context in which these materials were recovered will greatly enhance their interpretations.

In conclusion, the findings of this refitting analysis supports Zilhão and d'Errico's (1999a, 1999b) contention that until contextual integrity of artifacts in those levels pertaining to the Middle-Upper Paleolithic can be demonstrated, the role of Vindija Cave to understanding the techno-cultural processes of the Middle-Upper Paleolithic transition will remain unresolved.

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APPENDIX A
DESCRIPTION OF CHIPPED STONE REFIT SETS 1-29

Refit Set 1

Refit Set 1 consists of three blade or blade fragments of an unidentified black chert that have been removed from a single core in a reduction sequence. The core from which these originated was not identified among the chipped stone assemblage. The inner blade (#3348), and last of this sequence to be removed, is complete. The middle blade (#1146) and the outer blade (#KMB-117) are both medial fragments. None of the artifacts exhibit intentional retouch.

Refit Set 2

Refit Set 2 consists of a core (#802) and a blade (#795) of a distinct but unidentified mottled chert. The core continued to be reduced after the removal of this blade as indicated by a minimum of three blade scars on the face of the core, including at least one which would articulate to the ventral surface of the refitting blade (#795). Additionally, the maximum length of the refitting blade (#795) exceeds that of the core at the time of discard on both the proximal and distal ends. None of these blades were identified among the chipped stone assemblage. A distal flake fragment (#KMB-127), though unable to be articulated to either of the other two artifacts in this refit set, is very likely derived from the same cobble core.

Refit Set 3

Refit Set 3 consists of a flake (#720) and distal flake fragment (#3349) of unidentified grey chert. The complete flake has several dorsal scars and the ventral face of the distal flake fragment refits with one of these. The morphology of the dorsal scars indicates that these flakes were removed from a multi-directionally reduced core. This core was not identified among the chipped stone assemblage. Differential exposure to weathering processes has resulted in a distinct color difference between the two artifacts.

Refit Set 4

Refit Set 4 consists of a distal blade fragment (#747) and a core fragment (#1559). The core fragment has been further reworked into an atypical endscraper. At least two small blades were removed after #747 was removed from the core and before #1559 was removed. Articulating dorsal scars on both artifacts indicate that at least one flake was removed while both #747 and #1559 were still on the original core. The material is a distinctive caramel colored chert with numerous fossil and limestone inclusions. The source of this material is not known, however, it is very common in the chipped stone assemblage at Vindija Cave.

Refit Set 5

Refit Set 5 consists of a core fragment (#3366) and the proximal portion of a blade fragment (#605). Based on the width of the blade fragment and the corresponding flake scar on the core fragment, this blade was removed from the core fragment with the core fragment in its present state. The core from which these two artifacts were generated was not identified among the chipped stone assemblage, however, the morphology and fossil inclusions of two additional artifacts (#733 and #3328) suggests that they may have originated from the same core and/or cobble. Neither of the two artifacts exhibits intentional retouch. The material of Refit Set 5 is the same distinctive caramel chert as Refit Set 4.

Refit Set 6

Refit Set 6 consists of a small blade core (#724) and blade (#3344). When the core and the microblade are articulated the platform of the microblade extends 1mm above the existing striking platform. Flake scars on the striking platform indicate that it was prepared for further microblade removals after #724 was removed. There is, however, no evidence on the core to suggest that any additional microblades were actually produced and it is therefore very likely that #724 was the last microblade removed from this core. The microblade (#724) ended in a step termination and was not modified. These artifacts experienced differential weathering conditions post-depositionally as determined by the degree of patination present on the core (#3344) while the microblade (#724) has no macroscopic evidence of weathering. Refit Set 6 is composed of the same distinctive caramel chert of unknown origin that is common in the chipped stone assemblage, and of which Refit Sets 4 and 5 are also composed.

Refit Set 7

Refit Set 7 consists of a proximal flake fragment (#29) and a distal flake fragment (#112) that conjoin to form one large flake. The ventral face of an additional proximal flake fragment (#1557) refits to a dorsal scar on #29 and was removed from the core sometime before the conjoined flake (#29/112) was removed. None of these three artifacts exhibits further modification. These artifacts are of the same distinctive caramel colored chert as Refit Sets 4, 5, and 6. Chalky material is present on all three of the artifacts in Refit Set 7 and is possibly remnants of limestone matrix from which this material originated.

Refit Set 8

Refit #8 consists of an exhausted core (#3367) and a flake (#KMB-161). When articulated, the platform of the flake extends 2mm above the existing striking platform of the core. The striking platform was prepared with flake removals after the removal of #KMB-161 and at least two more attempt were made to produce flakes from this core before it was discarded. The flake was not modified further. These artifacts are of the same distinctive caramel chert as Refit Sets 4, 5, 6, and 7.

Refit Set 9

Refit Set 9 consists of a medial flake fragment (#705) and a complete flake (#716). Dorsal scars on the complete flake indicate that the core from which these two artifacts originated continued to be reduced after the removal of #705 and prior to the removal of #716 from the parent core. There is no evidence of retouch on either of these two artifacts although both exhibit irregular nibbling and edge damage on at least one margin. These artifacts are made from an unidentified green chert. Eight additional artifacts of this same lithic material were identified in the chipped stone collection and are considered to be from the same cobble due to consistency of light red banding and overall macroscopic appearance.

Refit Set 10

Refit Set 10 consists of two articulating core fragments (#KMB-192 and #KMB-193). The two fragments were separated by a blow, possibly with the use of an anvil, to the cortical surface situated opposite from an unprepared striking platform. Neither of these two artifacts exhibits evidence of additional reduction or retouch after the time of their separation. The material is an unidentified black and brown chert. Both of these artifacts show signs of post-depositional weathering in the form of patination and abrasion.

Refit Set 11

Refit Set 11 is composed of a cortical flake (#3299) and a core (#KMB-197). Several flakes were removed from this core after the removal of #3299, however, none of these flakes were identified among the chipped stone assemblage. Numerous internal flaws are visible in the material of the core and all flake scars are blocky and irregular. This core was likely abandoned as a result of its poor quality. Artifact #3299 is a primary decortication flake and river gravel cortex is present on its dorsal surface as well as on several surfaces of the parent core (#KMB-197). The material is an unidentified green chert, distinctive for it's thin white linear pattern. No other artifacts of this same material were identified among the chipped stone assemblage.

Refit Set 12

Refit Set12 consists of a tested cobble core (#KMB-198) and the only flake removed from it (#235). The flake was removed from an unprepared striking platform created when the cobble was split in half. Neither of the artifacts has been worked further, however, edge damage is present on both lateral margins of the flake. River gravel cortex is present on both of the artifacts in Refit Set 12 indicating that the grey basalt cobble was procured from a secondary source.

Refit Set 13

Refit Set 13 consists of two laterally split fragments (#KMB-204 and #KMB-205) that refit to form a complete flake, and a proximal flake fragment (#712) removed from the same cortical platform as the KMB-204/KMB-205 flake. The core from which these flakes were generated was not identified among the chipped stone assemblage. None of the artifacts in Refit Set 13 received any further modification or retouch. The material is unknown because chemical weathering has resulted in a grayish green chalky appearance that obscures all surfaces. Given that they derive from the same parent material KMB-204 and 712 would appear to have weathered similarly, while KMB-205 is considerably more chalky and was likely exposed to differential post-depositional weathering processes than the other two artifacts in this refit set.

Refit Set 14

This refit set consists of two fragments (#259 and #KMB-210) of a cobble core. A flake was removed from #259 after these two refitting fragments became separated but was not identified among the chipped stone assemblage. This cobble is an unidentified material whose composition, structure, and color has been obscured by chemical weathering resulting in a grayish green chalky appearance similar to that of Refit Set 13. In the case of Refit Set 14, the colors of the two refitting artifacts are considerably different from one another suggesting exposure to differential weathering processes.

Refit Set 15

Refit Set 15 consists of three flakes two of which, #KMB-212 and #KMB-213, were removed sequentially from the third flake, #KMB-211. The flake/core (#KMB-211) was removed from a parent core some time prior to the removal of #KMB-212 and #KMB-213. Weathering on the ventral surface of #KMB-211 suggests that this flake was produced and discarded, and that the two sequential flakes were removed some time after the weathering on the ventral surface of #KMB-211 had occurred and likely represents recycling of material from a previous occupation. An additional flake scar on #KMB-211 indicates that a third flake was removed from #KMB-211 at the same time as the refitting flakes (#KMB-212 and #KMB-213) however this flake was not identified among the chipped stone assemblage. None of these artifacts show evidence of intentional retouch.

These flakes were generated from a river cobble of grey basalt and river gravel cortex is present on all three artifacts. As mentioned above, #KMB-211 is weathered on its ventral face, however no weathering is noted on the other two flakes in this Refit Set.

Refit Set 16

Refit Set 16 consists of two flakes removed sequentially from the same cortical platform. #KMB-218 was removed prior to the removal of #KMB-219. A single flake scar on the dorsal face of the outer flake (#KMB-218) in this refit set is evidence of an additional flake removed from this core before #KMB-218. Neither the core nor the third flake were identified among the chipped stone assemblage. The two flakes comprising Refit Set 16 are of black basalt and both retain river gravel cortex on their platforms and dorsal surfaces.

Refit Set 17

Refit Set 17 consists of two flakes removed sequentially from the same cortical platform. #KMB-221 was removed immediately before #KMB-220. #KMB-221 is a laterally split flake and neither the associated flake fragment nor the core from which they originated were identified among the chipped stone assemblage. The lithic material of Refit Set 17 is very similar to that of Refit Set16 and it is possible that they derive from the same cobble core.

Refit Set 18

Refit Set 18 consists of a proximal flake fragment (#3144) and a distal flake fragment (#3112) that conjoin to form a single flake. This flake then refits to a third flake (#KMB-142). Both flakes were produced by bipolar reduction strategy. It is not known if the #3144/3112 flake broke as a result of cultural or natural processes. Dorsal scars on the inner of the two flakes (#3144/3112) indicate that at least two additional flakes were removed between the two flakes comprising the Refit Set. Neither of these flakes, nor the core from which they were removed, was identified among the chipped stone assemblage.

The lithic material of Refit Set 18 is an unidentified grey chert with yellow and orange mottling. River gravel cortex is present on both the platforms and distal ends of the two flakes in this refit set indicating that they were procured from a secondary source. Several other examples of this distinctive chert were identified in the chipped stone assemblage and are considered to have originated from a single cobble.

Refit Set 19

Refit Set 19 consists of a proximal blade fragment (#3039) and a flake (#3133). The ventral face of the flake refits to a dorsal scar on the blade, though because the blade is broken it is not possible to determine if the flake was removed directly from the blade, or if the flake was removed while the blade was still attached to a core. Additional flake scars on the dorsal face of the blade indicate that several flakes were removed directly from the blade after #3133 was removed.

The lithic material is an unidentified brown chert with numerous black specks and mottles. This material is fairly distinctive and several other artifacts were identified among the chipped stone assemblage that may derive from the same cobble as the two artifacts in Refit Set 19.

Refit Set 20

Refit Set 20 consists of two distal flake fragments that were sequentially removed from a core. Specimen #3386 was removed immediately after #594 and radial scars on both ventral surfaces indicate that the two flakes were removed from the same direction. The core from which they were removed was not identified among the chipped stone assemblage. The lithic material is a distinctive yellow and brown-banded chert. Three additional flakes and flake fragments of the same material were unable to be fit to Refit Set 20, however, it is highly probable that these artifacts all originated from the same cobble.

Refit Set 21

Refit Set 21 consists of a complete flake (#28) and a distal flake fragment (#123). The two articulate at the hinge termination of #28 and the distinctive flake scar created by the hinge termination is present on the distal margin of #123. #123 was removed after #28 and from the opposite direction. When articulated, dorsal scars on both flakes line up and indicate that at least two additional flakes were removed while both #28 and #123 were still attached to the core. Neither the core nor any additional refitting flakes were identified among the chipped stone assemblage. The lithic material is an unidentified black chert. It is distinctive among the chipped stone assemblage by its homogeneous appearance and the undulating surfaces produced by percussion. Several artifacts of the same material were identified in the chipped stone assemblage and likely belong to the same cobble.

Refit Set 22

Refit Set 22 consists of three pieces of angular debris (#3348, #KMB-72, and #KMB-77). It is unclear if these are shatter produced during the reduction process or if they represent a broken flake fragment. The raw material is fine-grained black basalt of unknown origin.

Refit Set 23

Refit Set 23 consists of a proximal (#44) and a distal (#257) blade fragment that conjoin to form a complete blade. It is uncertain if the break was the result of cultural or natural processes. Neither artifact exhibits evidence of intentional retouch, however edge damage is present on one margin of #257. The lithic material is an unidentified black chert, very similar to that of Refit Set 21, and possibly from the same cobble.

Refit Set 24

Refit Set 24 consists of two blade fragments (#KMB-123 and #907) that conjoin to form a unilaterally retouched endscraper on a blade. The cause of the break is unknown, however the distal fragment (#907) on which the endscraper is located was retouched laterally after the two were separated. The lithic material is an unidentified green chert with chalky, limestone-like cortex.

Refit Set 25

Refit Set 25 consists of a medial blade fragment (#2091) and a distal blade fragment (#3327) that conjoin to form a knife on a thin blade. The proximal fragment of this tool was not identified among the chipped stone assemblage. The two artifacts were broken by a snap fracture but there is no evidence that the blade was intentionally narrowed to facilitate breakage. In both cases, however, continuous flake scars extend from a lateral edge to the articulating edges of the two artifacts, or in other words, onto the location of the snap fracture. The fact that these two artifacts were worked post breakage is a strong indicator that the snap was cultural, whether intentional or accidental, and not the result of post-depositional processes. Although the articulating edges of these two artifacts have been partially altered and/or removed by retouch, the presence of flake/blade scars on the dorsal faces of both artifacts that match very well both in terms of location, size, and direction of radials, allow one to determine with confidence that these two artifacts were once a single artifact.

The material represented by the Refit Set 25 artifacts is an unidentified brown chert or possibly tuff. Four additional artifacts of this same material were identified in the chipped stone assemblage and while it was not possible to refit any of these to one another or to Refit Set 25, macroscopic characteristics of the stone indicate that they were likely derived from a single cobble. The two artifacts of Refit Set 25 have been differentially weathered such that #3327 has a waxy appearance and is smoother than #2091 and the four additional artifacts from the same cobble.

Refit Set 26

Refit Set 26 consists of a proximal (#3348) and a medial (#1541) fragment of a bilaterally retouched blade. The distal portion of this tool was not identified among the chipped stone assemblage. While both lateral edges of each of the two artifacts have continuous retouch indicating that it was modified as a complete tool, neither of these artifacts exhibits evidence of intentional modification after they were separated. Irregular nibbling consistent with edge damage is present on the articulating edge of #3388. The lithic material represented by Refit Set 26 is an unidentified, somewhat translucent, light brown mottled chert. Six additional artifacts were identified in the chipped stone assemblage as being of the same material as that of Refit Set 26.

Refit Set 27

Refit Set 27 consists of two flake fragments, proximal (#KMB-136) and distal (#KMB-137), that conjoin to form a complete flake tool. The two pieces were separated at the time of excavation as is evidenced by a fresh flake scars around the point of impact, probably with a metal tool. In addition, the articulating surfaces of the two artifacts are fresh and clean, with no sediment adhering to either. The thin veneer of patination present on these artifacts highlights these recent flake scars. The presence of patina on the entire artifact, including within flake scars made by marginal retouch, suggests that this flake tool was discarded and laid on the surface of the cave long enough to be chemically altered. The material is an unidentified light grey chert. No other examples of this material were identified among the chipped stone assemblage.

Refit Set 28

Refit Set 28 consists of two flake fragments (#268 and #440) that conjoin to form the medial portion of a flake. The separation of these two artifacts occurred along a natural imperfection in the raw material and it is not certain if this break occurred during the reduction process or as a result of post-depositional processes. The lithic material is an unidentified gray chert of unknown origins. The two artifacts differ in their degree of patination on their dorsal faces suggesting that they were exposed to differential weathering processes post-separation.

Refit Set 29

Refit Set 29 consists of a proximal blade fragment (#KMB-196) and a distal blade fragment (#3387) that conjoin to form a complete Aurignacian blade with bilateral retouch. Neither of the two artifacts exhibits evidence of post-separation modification and the cause of the break, rather cultural or natural, is not discernible. The material is an unidentified dark green chert of unknown origin. #KMB-196 is patinated to a greater extent than is #3387, and as a result is a much lighter shade of green with an overall chalky texture. The differential weathering of these two artifacts indicates that they were exposed to differential weathering processes after their separation.

Refit Sets 1-29 from the chipped stone collection of Vindija Cave

REFIT SET	ARTIFACTS	LEVELS	WEIGHT (grams)	LITHIC MATERIAL	CORTEX	TECHNOLOGY
1	3348 1146 KMB-117	E/F G3-4 Fd/s	6.1	Black Chert	River Cobble	Sequential removal of three secondary decortication blades
2	795 805	Fd/d Fd/d	33.8	Mottled Chert	River Cobble	A core and articulating blade
3	720 3349	G3 E/F	81.9	Grey Chert	None	A flake and distal flake fragment
4	747 1559	D G/F	7.5	Caramel Chert	None	A core fragment/tool and articulating distal blade fragment
5	605 3366	G1/G3 D	9.8	Caramel Chert	None	A core fragment and articulating distal blade fragment
6	724 3344	D E/F	12.8	Caramel Chert	None	A microblade core and microblade
7	29 112 1557	G2 Fd/d G/F	40.8	Caramel Chert	Limestone	Two conjoining flake fragments and articulating flake fragment
8	3367 KMB-161	D Fd/s	15.6	Caramel Chert	None	An exhausted core and flake
9	705 716	G3	16.3	Green Chert	None	A flake and medial flake fragment
10	KMB-192 KMB-193	G G4-H	42.9	Black and Brown Chert	River Cobble	Two fragments of a cobble core

11	3299 KMB-197	K/L K	28.9	Green Chert w/white lines	River Cobble	A primary decortication flake refit to a tested cobble core
12	235 KMB-198	G3-4 G	284.0	Grey Basalt, coarse-grained	River Cobble	A primary decortication flake refit to a tested cobble core
13	712 KMB-204 KMB-205	G/3 G G G3?	84.2	Unidentifiable	River Cobble	Two conjoining laterally split flake fragments articulate to a flake
14	259 KMB-210	G3-4 G	60.0	Unidentifiable	River Cobble	Two fragments of a split cobble core
15	KMB-211 KMB-212 KMB-213	E/F G G3? G3/G4	28.7	Grey Basalt, coarse-grained	River Cobble	Two flakes removed sequentially from a cobble core/flake
16	KMB-218 KMB-219	E/F Fd/s	20.1	Black Basalt, coarse-grained	River Cobble	Sequential removal of two primary decortication flakes
17	KMB-220 KMB-221	G G	18.9	Black Basalt, coarse-grained	River Cobble	Sequential removal of two primary decortication flakes
18	3112 3144 KMB-142	I+J K G/d	24.5	Grey chert w/yellow and orange mottling	River Cobble	Two articulating flakes reduced by bipolar technique; one of the flakes is composed of two conjoining fragments
19	3039 3133	I+J I+J	13.3	Brown chert	None	Unifacially worked blade fragment and thinning flake
20	594 3386	G1/G3 G1	5.8	Yellow and Brown banded chert	River Cobble	Two sequentially removed distal flake fragments

21	28 123	D+E Fd/d	6.4	Black chert	None	Two flakes articulating at a hinge termination, removed from opposing directions
22	3348 KMB-72 KMB-77	Fd/s Fs Fd	3.1	Black Basalt, fine-grained	None	Angular debris
23	44 257	Fs G3-4	8.2	Black Chert	None	Two blade fragments conjoin to form a complete blade
24	907 KMB-123	F G/g	15.4	Green Chert	Limestone	Two fragments conjoin to form an endscraper on a unilaterally retouched blade
25	2091 3327	F E	8.1	Brown Chert	None	Two blade fragments conjoin to form a thin bilaterally retouched blade
26	1541 3388	G/F G1	11.7	Brown mottled Chert	River Cobble	Two blade fragments conjoin to form a bilaterally retouched blade
27	KMB-136 KMB-137	G1-5 G3-5	8.0	Light Grey Chert	None	Two fragments conjoin to form a complete flake tool; broken during excavation
28	268 440	G3-4 G3-4	7.8	Grey Chert	None	Two flake fragments conjoin at a natural flaw in the raw material
29	3387 KMB-196	G1 G	41.5	Green Chert	None	Two fragments conjoin to form a bilaterally retouched blade

APPENDIX B
NON-CHIPPED STONE REFITS

Refit Set 30

Refit Set 30 consists of two conjoined fragments of a river cobble that became separated as a result of natural processes (salami slices). The material is unidentifiable due to the effects of chemical weathering. One of the two artifacts (#1279) is notably more patinated than the other (#KMB-206) indicating differential exposure to weathering processes.

Refit Set 31

This refit set consists of two fragments (#544 and #KMB-207) that conjoin to form a complete cobble broken by natural processes. The presence of cortex and the morphology of the two conjoined fragments suggest that they derive from a river cobble of unknown lithic material. Both are excessively weathered, obscuring the characteristics of the raw material. As with Refit Set 30, the two fragments have been weathered to different degrees indicating differential exposure to post-depositional weathering processes.

Refit Set 32

Refit Set 32 is composed of four fragments of a tabular river cobble of a coarse-grained black basalt. Two of the fragments are "salami slices" and likely were separated as a result of hydro-thermal action (#KMB-216 and #KMB-217). Once conjoined these two artifacts conjoin to #KMB-215 and #KMB-215 then conjoins to the largest of the fragments, #KMB-214. Only #KMB-216 shows signs of post-depositional weathering.

Refit Set 33

Refit Set 33 consists of a river pebble and a single conjoining fragment. All edges are quite fresh and no sediment is present on either of the articulating surfaces. It is very likely that this cobble was broken as a result of excavation activities and possibly even curated as a single artifact. Both artifacts have received the same level designation (Level G5) and only the larger of the two was given a catalog number (#587).

Refit Set 34

Refit Set 34 is the only non-lithic refitting set. This is composed of the proximal (#3440) and medial (#3456) portions of a broken bone point. The two conjoin to form a nearly complete Mladeč type bone point. The distal portion was not identified among the bone tool assemblage. Encrusted sediments on the articulating surfaces of both fragments of the bone point suggests that the point was broken, as a result of post-depositional processes prior to its recovery during excavation.

Refit Sets 30-34 from the non-chipped stone collection of Vindija Cave

REFIT SET	ARTIFACTS	STRATA	WEIGHT (grams)	MATERIAL	COMMENTS
30	3387 KMB-206	G1 G	16.1	Unidentified stone	Two river cobble fragments broken by freeze-thaw
31	544 KMB-207	G4-5 G	52.9	Unidentified stone	Two river cobble fragments broken by natural processes
32	KMB-214 KMB-215 KMB-216 KMB-217	G	735.6	Black coarse-grained basalt	Four fragments of a tabular river cobble broken by natural processes
33	587 KMB-183	G5	9.9	Unidentified stone	Two fragments of a river pebble, broken during excavation
34	3440 3456	G1 F/s	13.4	Bone	Conjoining medial and proximal portions of a bone point